The Case of the Mysterious Pool Deposits

by Scott Webb

The 80,000-gallon resort pool, which had been operating flawlessly for years, had suddenly developed a very expensive, very troubling problem. For some unknown reason, large deposits of a dull white material were collecting on the heat exchanger, blocking flow and necessitating a $900 repair bill.

Even a novice service person would suspect calcium carbonate scale, but the water was balanced and did not contain unusually high levels of that mineral. And the staff insisted it had done nothing different from previous years when they'd been trouble free. Why should a pool heater that had never seen significant deposits before suddenly look like a billboard for Rock City?

Each time it happened, the pool had to be shut down and the owners were presented with a $900 invoice. By the third incident, they decided it was time to bring in outside help.

That's when they called Que Hales, a detective who specializes in such matters in the Tucson area. (Hales manages the Tucson branch of Pool Chlor, a large residential service business, and also does research, education and consulting as a partner in a company called onBalance.)

Arriving on the scene of the crusty buildup, Hales immediately assembled a list of the usual suspects, and started asking questions. The staff told him that the primary sanitizer was sodium hypochlorite (bleach) — both chlorine and acid being fed through automated systems.

The acid being used, they said, was a special "buffered" acid. When Hales inquired about that product, he was told that they had begun using the buffered acid as a safety precaution about six months ago. Use of the buffered acid was considered a safety measure, as it was less likely to cause burns if spilled on the skin of the operator. Hales only nodded, significantly.

Before he left the scene, he bagged some physical evidence for analysis. It was an intriguing case, and like an episode of CSI, it would hinge on the results of lab tests behind the scenes.

Analysis of the pool water showed an extremely elevated level of phosphate. Armed with a new line of inquiry, Hales returned to the scene of the mineral buildup.

"I went back and started asking some questions," Hales says. "They had no idea where the phosphate had come from. They said, 'The only thing we are doing differently since the problem started is using the acid.'"

Hales had heard of this product being used for acid washing pools but not for regular water maintenance. Still, pursuing the lead to its logical end, Hales took a sample of the acid and had it analyzed.

Bingo. Lab results confirmed that the buffer in the acid the pool operators were using was indeed phosphate-based. Only a few loose ends remained to be tied up.

"I then got samples of the solid material that was plugging up the heat exchangers in the heater and sent it to a research lab so they could do x-ray diffraction on the material," Hales says. "And they determined that the material that was plugging up the heater was calcium phosphate."

Phosphate Rising

Although Hales' case has been placed in the file cabinet marked "closed," concerns over calcium phosphate in the industry remain very much an open topic.

The interest is fairly recent. The basics of calcium carbonate chemistry have been thoroughly discussed among techs for decades, as many a pool heater or salt chlorine generator cell has been found with a flaky scale of calcium carbonate, deposit of which is driven by high pH and heat. But calcium phosphate has only surfaced in the last few years on pool forums and trade articles, buoyed along by the interest in phosphates in general and their role in pool problems.

Calcium phosphate and calcium carbonate produce similar symptoms — cloudy pool water, damaged heat exchangers and a dull white film on surfaces, but calcium phosphate is not driven out of solution by high pH. It's barely soluble in pool water at normal temperatures (given sufficient levels of calcium and phosphate), but heat really drives the reaction, causing it to precipitate at the heater.

But From Where?

The sources of phosphates in a pool are frequently man-made, often additives or fill water.

Although Hales' phosphates came from a buffer in the acid used to lower pH, Terry Arko, product specialist, SeaKlear Pool And Spa Products, notes that a more common source is metal remover products which contain polyphosphonates [such as HEDP]. When these products are used in pools with high calcium levels, Arko says, it can lead to the formation of calcium phosphate scale.

"Most metal removal and prevention products are phosphoric or phosphonic acid based. While these are effective at dealing with certain metal stains, they also eventually break down to orthophosphate that will accumulate over time. When there are high levels of orthophosphate combined with calcium and you have a high temperature such as at the point of the heat exchanger, the potential for calcium phosphate scale to precipitate and damage the exchanger is very high.

"Another factor causing an increase in calcium phosphate scale could be the higher levels of orthophosphate from source water added to high-calcium water. The higher levels of orthophosphates from source water could be causing calcium phosphate scale formation particularly on heat exchangers."

This jibes with the experience of Steve White, owner of Underwater Pool Masters, West Boylston, Mass., and educational director for APSP's Region IX. White says source water high in phosphate has caused issues in the pools he takes care of.

"I've made an issue of this in my CPO classes," he says. "In my own town, West Boylston, they've admitted that town water 'is treated at the source with a poly-phosphate blend, which is added to sequester manganese and iron because they tend to cause staining of fixtures.'

"The reality is that almost every town around us is doing this, and the reason is because people are complaining of metal staining on their toilets, sinks and dishwashers. You know, you get a nice new porcelain sink in a nice new home, and the water is coming in through pipes that are older, where they can pick up metal — so they add this product to the source water to address the complaints about staining from homeowners.

"What I have discovered is that, especially in pools where they've got a lot of topping up the pool due to evaporation loss, that you're getting a lot of phosphates accumulating in the pool through the source water. And if you don't remove it, as you are evaporating water out of the pool and adding more from source water, the phosphates are just building up."

Fleeting Deposits

That accumulation of phosphate does not necessarily cause a problem. Even when phosphates do build up in a pool, and combine with calcium in the water to form calcium phosphate, these solid particles of calcium phosphate suspended in water are likely to be caught by the filter. The process of deposition on a surface in the form of scale takes certain conditions, notes Karen Rigsby, technical services leader at Chemtura.

"It's important to remember that just because something precipitates does not mean it will become scale. I also think it's important to point out the difference between how calcium carbonate scale is formed (calcium carbonate is typically the type of scale people talk about) versus calcium phosphate, because they are a little bit different.

"A lot of people think that calcium phosphate and calcium carbonate scale form in the same way. Usually when calcium carbonate forms, the pH goes up, the calcium carbonate becomes insoluble, falls out and adheres to a surface, particularly in a chlorine generator cell because the pH is so high in there.

"It's not the same for calcium phosphate. It isn't driven out by high pH. It's kind of insoluble already, so it will start to precipitate. But what generally happens, because it just begins to precipitate and the water is moving, it normally gets caught on the filter or something like that."

Fast-moving, turbulent water flowing around the heat exchanger will often keep solids from sticking to that surface, Rigsby adds.

"You could think of when you made chocolate milk when you were a kid and when you stirred it up all the chocolate stayed in but when you quit all the powder fell to the bottom. That's exactly what happens with the calcium phosphate. Because there's so much sheer inside of a heating element it never has a chance to fall. So the likelihood that it's going to adhere there is very, very low. That high velocity just doesn't give it any time to fall out."

Keep It Down

To lower the risk of calcium phosphate adhering to and clogging the heater, and to help fight other phosphate related problems, Arko recommends regular phosphate testing and the use of phosphate removers to keep levels down, especially in high water hardness areas or where calcium hypochlorite and calcium chloride are used in pools.

"It is particularly important if phosphate based metal removal or sequestering products are being used regularly in heated pools where calcium is present," he says. "This would include pools in high hardness areas such as Arizona or pools that regularly use calcium hypo-chlorite."

That's what Hales did in the denouement of The Case of the Mysterious Deposits on the resort pool heaters in Tucson.

"Since the pool was located at a country club/resort, it was heavily used and the management was unhappy about draining the pool to remove or dilute the phosphate level. I recommended that the staff use phosphate reducers, which they did successfully," Hales says. "When the phosphate level was lowered to a 'background' level, the maintenance staff opened the heaters and looked for continuing deposits in the heat exchangers, but the process had ceased."

Cool It!

It's like a radiator in a car. If you're doing 80 mph down the highway for a while, and then pull over and quickly switch off the motor, that's the hottest moment your radiator will ever see (assuming you don't have a car that's designed to keep its radiator running after shutdown to fight this very problem), as the cooling air coursing through it stops and the engine's heat continues to build.

A pool heater works the same way. When the pump is shut down at the same time as the heater (or God forbid, before) the heater produces its hottest water. Not only that, the water is then allowed to sit and simmer next to the exchanger, precipitating every molecule of calcium it possibly can, and allowing those flakes of calcium (whether in the form of calcium carbonate or calcium phosphate) to get a good firm grip on the heat exchanger.

Hales explains, "In normal operation, you're running the water through the heat exchanger, and most of the precipitated calcium ends up out in the pool and it either re-dissolves or gets filtered out.

"If you shut down the pump without pre-cooling the heater on a regular basis, you will build up a lot of calcium carbonate (and calcium phosphate, if phosphate is present) inside the heater.

"Normally in a pool heater, when you find people are clogging it with calcium, it's either because the water is really, really high in calcium to begin with — although even then if it's flowing fast enough it usually won't be a problem.

"But what really causes a problem is when people have the heater on and then they shut off the pump for whatever reason without running cool water past the heater to allow it to cool down first before they shut off the pump.

"When you do shut the pump and the heater down at the same time, you're allowing superheated water to sit next to the heat exchanger, and that's where you can get a big buildup of calcium."

In the case of the deposits on the resort heater mentioned earlier in this story, Hales says, the resort operators were pre-cooling the heater, which prevented the buildup of calcium carbonate, but there was so much phosphate in the water, which precipitates at a lower temperature in the form of calcium phosphate, to plug the heater. —S.W.

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