The Relationship of ORP With PPM
& Why Calculated PPM Cannot be Consistently Accurate

In my travels around the country, I find that most people could care less about ORP and rely solely on PPM most likely because they don't understand ORP or because health departments do not recognize it and specify PPM free chlorine residual standards.

ORP is a qualitative measurement and PPM is a quantitative measurement. I have often seen pools and spas with measurements acceptable to health department standards with low ORP levels ineffective to properly sanitize and oxidize the water. Conversely, I have seen water that would not pass a health department inspection in regards to free chlorine residuals that have excellent water quality.

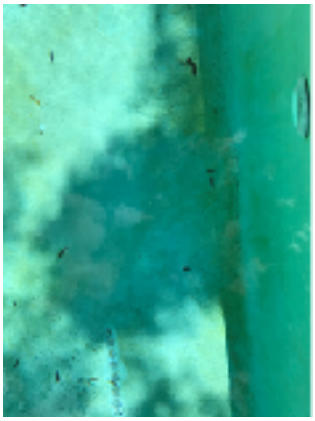
The WHO standard of having a minimum ORP of 650mV is outdated due primarily to changes in ORP sensor technology and now the standard is 720mV as documented here. http://www.who.int/water_sanitation_health/bathing/srwe2chap5.pdf

5.10.4 Oxidation–reduction potential (ORP) The oxidation–reduction potential (also known as ORP or redox) can also be used in the operational monitoring of disinfection efficacy. In general terms for swimming pools and similar environments, levels in excess of 720 mV (measured using a silver/ silver chloride electrode) or 680 mV (using a calomel electrode) suggest that the water is in good microbial condition, although it is suggested that appropriate values should be determined on a case-by-case basis.

It is important to also note that having proper circulation and filtration is important to maintain safe water quality along with monitoring phosphate and nitrate levels.

The best way to understand how a pool can be have acceptable free chlorine and pH readings but not be properly sanitized can be seen here on a chemical automation system that measures Free Chlorine, ORP & pH

Comparing free chlorine and pH to ORP. First line of data is with pool water containing 80 ppm of cyanuric acid. Second line shows spa water with 30 ppm of cyanuric acid.



These readings show a free chlorine reading well above minimum standards but with 100 ppm of cyanuric acid. This pool has a problem with yellow algae that would most likely not exist with proper ORP levels.

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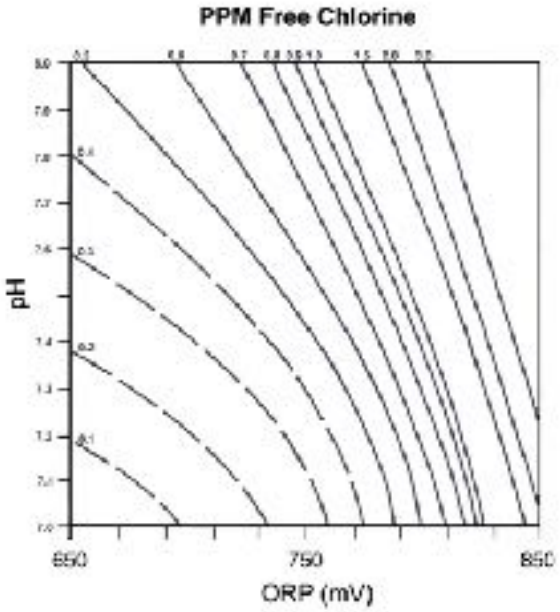
So why is it that calculated PPM not be accurate? First, let me say there are some exceptions. I have seen pools and spas without cyanuric acid can be fairly close in the conversion accuracy, especially in indoor pools and spas that are properly sanitized without combined chlorine but in the real world this is not the case. Here is a typical ORP/PPM conversion chart.



The biggest problem with ORP to PPM conversions in the real world is varying degrees of usage, weather, fertilizers blowing into pools, treatment chemicals and cyanuric acid. Below are real world examples of variations of the ORP/PPM relationship with variables such as algae treatments and varying levels of cyanuric acid as monitored by controllers testing DPD Free Chlorine, ORP, pH & Temperature.

1. CYA = 90
2. CYA = 65

1. CYA = 0
2. CYA = 0

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1. CYA = 100
2. CYA = 0

1. CYA = 0
2. CYA = 0

1. CYA = 10
2. CYA = 100

1. CYA = 0
2. CYA = 0

1. CYA = 120
2. CYA = 80

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As you can see, the ORP/PPM relationship is all over the place. The biggest variable in these examples is the amount of cyanuric acid in the water. The levels in the above examples range from 0-120 PPM. Cyanuric acid is typically added at the beginning of the season and the level will decline due to splash out and backwashing unless more is added monthly. There is no algorithm I have seen that knows how much cyanuric acid is in the water, sunlight intensity or night time which all affect ORP levels at a given PPM level. This is why calculated PPM is nothing more than a guess. It can be calibrated for specific conditions but as soon as those conditions change, it will be off.

The real world shows there are so many variables that the only practical way to accurately test for FAC in PPM is with DPD or selective membrane free chlorine sensors.

Just adhering to your local health jurisdiction guidelines will not guarantee you will not have problems. To ensure optimum water quality, looking at the big picture including ORP, FAC, pH and cyanuric acid levels will help in managing the quality of your water.

- Lance Fitzsimmons