

# WATER CHEMISTRY

Ozone carries an oxidation potential that supercedes that of three (3) of the four (4) halogens currently being used in oxidation and disinfection of water. Of the four (4) halogens, two (2) are predominantly used in swimming pool and spa applications. The two (2) being chlorine and bromine.

If you were to use a scale with chlorine as the base, of one (1) in oxidation potential, the following is a list of the ranking for commonly used oxidants.

## Oxidation Potential of Standard Oxidants

Oxidant	Oxidation Potential Volts	Oxidation Power
Fluorine	3.06	2.25
Hydroxyl Radical	2.80	2.05
Atomic Oxygen	2.42	1.78
Ozone	2.07	1.52
Hydrogen Peroxide	1.77	1.30
Permanganate	1.67	1.22
Hypochlorous Acid	1.49	1.10
Chlorine	1.36	1.00
Bromine	.78	.57

Basically, if this were to be summarized one could assume ozone has more than twice the oxidation potential of either chlorine or bromine. Because of this, ozone will disinfect water 3200 times faster than chlorine and 5,600 at times faster than bromine. In addition to this, oxidation efficiency of organics to biodegradable compounds (that are filterable) is increased by 80%.

To add further to this would be the ability to oxidize minerals such as iron, Fe, to  $Fe_2O_3$ . The new molecule  $Fe_2O_3$  precipitates from the water and settles to the bottom of the pool. A good indication of this has taken place in a red color in the backwash of the filter or the pool itself.

As well as iron, Fe, alkalinity can be affected to. The following is a list of the three (3) types of alkalinity found in water.

### 1. Bicarbonate Alkalinity

This would be the most common and most desirable type of alkalinity.

### 2. Carbonate Alkalinity

This would be the second most abundant type of alkalinity and should never construe more than 10% of total alkalinity due to its harshness.

### 3. Hydroxide Alkalinity

This is the least abundant type of alkalinity and is exceedingly caustic in action. In even weak hydroxide solutions, organics are quickly destroyed by this type of alkalinity. Due to this, even small levels are undesirable in swimming pool applications.

Contrary to popular belief, PH is not a measurement of alkalinity. The following is a description of both PH and alkalinity.

**pH** - Water in nature tends to be quite complex. Basically, the formula for a molecule of water is  $H_2O$ . However, a small part of water dissociates to form  $H^+$  (hydrogen ions) and  $OH^-$  (hydroxyl ions). The hydrogen ions form what we call pH. The definition for this is "The logarithm of the reciprocal of the hydrogen ion concentration in moles per liter".

**Alkalinity** This is a measurement of hydroxyl ions in water. The addition of certain compounds, that can be measured in total hardness as well, will result in the formation of hydroxyl ions. The compounds are carbonates, bicarbonates and hydroxides.

Even though there is a distinct difference between pH and alkalinity there will be a distinct correlation between the two. The following chart will show this relationship.

H+ Concentration	pH	OH- Concentration
0.000000000000001	14.0	1.0
0.00000000000001	13.0	0.1
0.0000000000001	12.0	0.01
0.000000000001	11.0	0.001
0.0000000001	10.0	0.0001
0.00000001	9.0	0.00001
0.0000001	8.0	0.000001
0.000001	7.0	0.0000001
0.00001	6.0	0.00000001
0.0001	5.0	0.000000001
0.001	4.0	0.0000000001
0.01	3.0	0.00000000001
0.1	2.0	0.000000000001
	1.0	0.0000000000001

Ozone in itself will not affect pH and alkalinity. Generally wide fluctuations in pH can be experienced daily. Alkalinity will tend to be much more stable but should be monitored when problems occur.

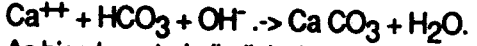
When looking at start-up of a pool chemical balance should be considered in terms of both pH and alkalinity. Because algae requires carbon dioxide as a food source as pH goes up carbon dioxide is being consumed and this would usually be due to algae growth. Because of this, if water is maintained at a pH below 7.6, algae growth can usually be deterred. If pH is allowed to exceed 7.6, algae can begin to grow and turn water a cloudy dark green color. When this occurs, ozone will require extended time to overcome this problem. Due to this, we recommend using an algaecide to assist in overcoming algae growth at this point as well as acid to adjust pH below 7.6. Because ozone is affected by high pH as well, a shock treatment for additional oxidation potential would be recommended too. To give you an idea of the effects pH has on ozone, the following chart has been developed.

### Ozone Half-Life

pH	Ozone Half-Life
7.0	18 minutes
8.0	10 minutes
9.0	5 minutes
10.0	2 minutes

As you can see by the chart, as pH goes up, degradation of ozone residual accelerates rapidly. However, this process is not as drastic as chlorine. For this reason, as pH goes up, oxidation potential is lost with any chemicals being used for disinfection and oxidation.

Another factor to be considered in relationship to ozone, would be the mechanisms of reaction. These processes are once again initiated by pH and ultimately will affect total alkalinity. The first mechanism would be through reactions with the ozone molecule. This reaction tends to be very stable and does not tend to drastically alter pH or total alkalinity. The second would be the formation of free radicals. As the pH goes up the free radical reaction tends to dominate. One of these free radicals would be the hydroxide ion as previously stated, this ion is corrosive and tends to react with other ions very quickly. Due to this, when the pH exceeds 7.6, you can begin to create enough hydroxide ions to react with bicarbonated alkalinity. The following equation will give some indication to how this reaction takes place.



As bicarbonated alkalinity is converted to carbonated alkalinity, you will reach a point of saturation from the calcium ions