



# Chemistry / Service Manual



Pools & Spas



# MineralPURE®

## Chemistry / Service Manual



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**I.**

# **Water Chemistry**

# A. Glossary of Water Treatment Terms

*The following compilation includes commonly used industry terms and their definitions*

**Absolute:** Used in reference to micron rating of cartridge filters. Refers to an exact size of particles that will not pass through, and all particles larger than that size are trapped within the filter.

**Acid:** Chemicals such as muriatic acid or sodium bisulfate used to lower pH for alkalinity.

**Acid Demand:** A measure of the amount of acid required to reduce pH to a predetermined level. This can be accomplished by use of an acid filtration procedure (Acid Demands Test).

**Activate Carbon:** Granulated active carbon used to remove tastes, odor, chlorine, chloramines and some organics of water.

**Absorb:** the process by which molecules or colloids physically adhere to the surfaces of solids.

**Algae:** Plant-like organisms which flow in water due to lack of sanitizers and certain warm temperatures.

**Alkalinity:** SEE TOTAL ALKALINITY.

**Anion:** Negatively charged ion.

**Aquifer:** Any geological formation containing water; one that supplies water for wells, springs, etc.

**Backwash:** Reverse of a solution's flow through a system. Often used as a cleansing mechanism in sand and dual media filters.

**Bacteria:** Disease-potential organisms requiring control by sanitizing agents. Any of a class of microscopic plants having round, rod-like spiral or filamentous single cell or non-cellular bodies, often aggregated into colonies in soil, water, organic matter or the bodies of plants and

animals and being autotrophic (self-generative), saprophytic (digests chemicals already present in their environment) or parasitic.

**Bactericide:** material capable of inhibiting or destroying bacteria.

**Balanced water:** Water that is neither corrosive nor scaling (in relation to pH, total alkalinity, calcium hardness, and temperature factors). The Langelier Index for perfectly balanced water equals zero.

**Base Demand:** A measure of the amount of alkali material required to raise pH to a predetermined level. This can be accomplished by use of base titration procedure (Base Demand Test).

**Binders:** When used in reference to cartridge filters, refer to chemicals used to hold, or bind, short fibers together in a filter.

**Blinding:** The fouling or plugging of pores in a membrane, usually a gel-like substance.

**Bromine:** Chemical sanitizer that kills bacteria and algae.

**Buffer:** Chemical that resists pH change, e.g. sodium bicarbonate.

**Calcium Hardness:** A measure of the calcium salts dissolved in water.

**Cation:** positively charged ion.

**Chemical Solution Feeder:** A pump used to meter chemicals such as chlorine or polyphosphate into a water supply.

**Chloramine:** A combination of free chlorine and ammonia gas that retains its bactericidal qualities

for a longer time than does free chlorine.

**Chlorine:** Chemical sanitizer that kills bacteria and algae. A very toxic biocide. A halogen element isolated as a heavy irritating greenish-yellow gas of pungent odor used especially as bleach, oxidizing agent and a disinfectant in water purification.

**Chlorine Combined:** The reaction product of chlorine with ammonia or other pollutants; also known as chloramines.

**Chlorine Free:** Chlorine available to kill bacteria or algae.

**Colloid:** Material of very fine particle size, usually between 10<sup>-7</sup> cm in diameter.

**Colloidal-matter:** A gelatinous or mucinous substance suspended in water that can pass through even the finest sediment filter.

**Compaction:** Decline in flux as a result of applied pressure compressing a reverse osmosis or ultrafiltration membrane.

**Concentrate:** The portion of a feed stream that retains the ions, organics and suspended particles that were rejected during the cross flow filtration process.

**Condensate:** Water obtained through evaporation and subsequent condensation.

**Contaminant:** Object that is a source of contamination.

**Cross flow:** A precise separation of the components of a fluid by semi-permeable membrane through the application of pressure and flow.

**Cyanuric Acid:** Chemical used to prevent the decomposition of chlorine by ultra-violet (UV) light.

**DI (Deionization):** Uses ion exchange resin to remove salts from the water.

**Demineralization:** The process of removing minerals from water e.g. deionization, reverse osmosis and distillation.

**Disinfection:** Destruction of bacteria in a water supply or distribution system.

**Dissolved Solids:** Includes colloidal and small suspended particles. Size is less than 1.2 in diameter.

**Distillation:** Steam from boiling water is condensed and stored. Most contaminants do not vaporize and therefore do not pass to the condensate. Removes nearly 100 percent of salts and those organics that do not have a vaporizing temperature near or below that of water.

**Effluent:** The output stream exiting the system—often the waste stream.

**Element:** A basic building block of the system. Often used in reference to membrane element; part of system containing the membrane for use in separations.

**Feed:** The input solution to a system.

**Filter cube:** The accumulated particles on a filter surface.

**Filtrate:** the portion of the feed stream that has passed throughout the membrane.

**Flocculent:** Chemical which, when added to water, causes particles to coagulate into larger, settleable groupings (flocs).

**Flux:** The membrane throughput, usually expressed in volume per unit time, such as “gpd”.

**GPD:** Gallons per day.

**GPG:** Grains per gallon. Equal to 17.1 mg/l.

**Ground water:** water confined in semi-permeable rock layers.

**Hardness:** the concentration of calcium and magnesium salts in the water.

**Heavy Metals:** Metals having a high density or specific gravity. A generic term used to classify contaminants such as cadmium, lead and mercury.

**Hydrogen Sulfide:** A toxic gas (H<sub>2</sub>S) that is detectable by a strong “rotten egg” odor.

**Hydrologic Cycle:** The term used to describe how water travels through the environment by evaporation, condensation and precipitation.

**Ion Exchange:** a chemical reaction in which ions are exchanged in solution. Water softening and deionization are common applications of ion exchange.

**Laminar:** non-turbulent flow membrane,

**Langlier Index:** a mathematically-derived factor obtained from the values of calcium hardness, total alkalinity. And pH at a given temperature. A Langlier Index of zero indicates perfect water balance (i.e., neither corroding nor scaling.)

**Magnesium Hardness:** a measure of the magnesium salts dissolved in water – not a factor in water balance.

**Membrane:** Polymer film utilized as the semi-permeable separation mechanism in reverse osmosis, ultrafiltration and microfiltration.

**MG/1:** Milligrams per liter. Equivalent to parts per million (PPM)

**Micron:** 10<sup>-4</sup> centimeter. 25.4 microns = 0.001 inch = one mm

**Module:** the membrane element combined with the membrane element housing.

**Muriatic Acid:** An acid used to reduce pH and alkalinity. Also used to remove stain and scale.

**Nominal:** when used in reference to micron rating of cartridges filters, refers to an approximate size particle that will not pass through a filter.

**Osmosis:** The spontaneous flow of water from a less concentrated solution to a more concentrated membrane occurring until energy equilibrium is achieved.

**Osmotic Pressure:** Measurement of the potential energy difference between the solutions on either side of a semi-permeable membrane.

**Oxidizing Filter:** Filters that use a catalytic media, such as manganese oxides, to oxidize iron, manganese and other impurities from water.

**Ozone:** A form of oxygen used to disinfect water.

**Particulate:** Minute, separate particles.

**Permeable:** Allowing some material to pass through.

**Permeate:** The portion of the feed stream that passes through the membrane.

**pH:** A measure of the acidity of water. The pH scale runs from 0 to 14 with 7 being the mid-point or neutral. A pH of less than 7 is on the acid side of the scale with 0 as the point of greatest acid activity. A pH of more than 7 is on the basic (alkaline) side of the scale with 14 as the point of greatest basic activity.

**Phenol Red:** a water-soluble dye used as a pH indicator, changing from yellow to red over pH 6.6 to 8.0, and then turning a bright pink color above pH 8.1.

**Polymers:** a chemical compound with many repeating structural units.

**Pore:** An opening in a membrane which allows

certain components to pass through, but not others.

**Porous:** A material which allows certain substances to pass through its pores.

**PPB:** Parts per billion.

**PPM:** Parts per million.

**PSI:** pounds per square inch (pressure).

**Regeneration:** is carried out using either an acid or alkali to remove the accumulated actions or anions, respectively. At the same time, the action exchanger takes on hydrogen ions to restore themselves to the original hydrogen or hydroxide form, respectively.

**Rejection:** Material not being allowed to pass through a membrane.

**Resin:** Specially manufactured polymer beads used in the ion exchange process to remove dissolved salts from water.

**Reverse Osmosis:** The separation of one component of a solution from another component by means of pressure exerted on a semi-permeable membrane. Utilizes membrane pore sizes from 5A to 20A.

**Scale:** Crust of calcium carbonate, the result of unbalanced pool water.

**Semi-permeable:** Able to allow certain size material to pass through while rejecting other size material.

**Soda Ash:** Chemical used to raise pH and total alkalinity (sodium carbonate).

**Sodium Bisulfate:** Chemical used to lower pH and total alkalinity (dry acid).

**Soft Water:** Water containing less than 17 PPM calcium or magnesium.

**Solute:** dissolved particles in a solvent.

**Stabilizer:** See CYANURIC ACID.

**Superchlorination:** Application of large dosages of chlorine to destroy build-up of undesirable compounds in water.

**Suspended Solids:** Includes settle-able particles less than 1.2 in diameter.

**Titration:** A method of testing by adding a reagent of known strength to a water sample until a specific color change indicates the completion of the reaction.

**Total Alkalinity:** A measure of the acid neutralizing capacity of water which indicates its buffering ability, i.e., the measure of its resistance to a change in pH. Generally, the higher the total alkalinity, the greater the resistance to pH changes.

**Total Dissolved Solids:** The accumulated total of all solids that might be dissolved in water.

**Turbidity:** Muddy, clouded, stirred-up sediment, silt, clay, etc.

**Ultrafiltration:** Separation of one component of a solution from another component by means of pressure exerted on a semi-permeable membrane. Utilizes membrane pore sizes from 10-A to 0.1.

**Ultraviolet Disinfection:** A light that is used to kill or deactivate pathogens such as bacteria and viruses. Unlike chemical disinfectants such as chlorine, UV does not leave a residual product.



# B. Metric Conversion Chart

For your convenience, Clearwater Enviro Tech has formulated metric and English conversions, as well as International. You will find these charts not only handy in volume of water, but area, mass, length, and temperature.

## Into Metric

*If you know Multiply by To Get*

### Length

Inches	2.54	Centimeters
Feet	30.00	Centimeters
Yards	0.91	Meters
Miles	1.60	Kilometers

### Area

Sq. Inches	6.50	Sq Centimeters
Sq. feet	0.09	Sq. Meters
Sq. Yards	0.80	Sq. Meters
Sq. Miles	2.60	Sq. Kilometers
Acres	0.40	Hectares

### Mass (weight)

Ounces	28.00	Grams
Pound	0.45	Kilograms
Short ton	0.90	Metric Ton

### Volume

Teaspoons	5.00	Milliliters
Tablespoons	15.00	Milliliters
Fluid ounces	30.00	Milliliters
Cups	0.24	Liters
Pints	0.47	Liters
Quarts	0.95	Liters
Gallons	3.785	Liters
Cubic feet	0.03	Cubic meters
Cubic yards...	0.76	Cubic meters

### Temperature

Subtract 32 from Fahrenheit, then multiply by five-ninths

## Out of Metric

*If you know Multiply To Get*

### Length

Millimeters	0.04	Inches
Centimeters	0.40	Inches
Meter	3.30	Feet
Meters	1.10	Yards
Kilometers	0.62	Miles

### Area

Sq. Centimeters	0.16	Sq. Inches
Sq. Meters	11.10	Sq. Feet
Sq. Meters	1.20	Sq. Feet
Sq. Kilometers	0.40	Sq. Miles
Hectares	2.47	Acres

### Mass (weight)

Grams	0.035	Ounces
Kilograms	2.20	Pound
Metric Tons	1.10	Short Ton

### Volume

Milliliters	0.18	Teaspoons
Milliliters	0.06	Teaspoons
Milliliters	0.03	Fluid Ounces
Liters	1.20	Cups
Liters	2.10	Pints
Liters	1.06	Quarters
Liters	0.26	Gallons
Cubic Meters	35.00	Cubic Feet
Cubic Meters	1.30	Cubic Yards

### Temperature

Multiply Celsius by nine-fifths, then add 32

# Conversion Tables (continued)

## Methods of Expressing Water Constituents on Water Analysis: International

1 U.S. grain/gallon .....	1 grain, calcium carbonate, per U.S. gallon of water
1 part per million (PPM .....	1 part calcium carbonate, per 1,000,000 parts of water
1 part per million (PPM .....	in metric = 1mg/L (one milligram per liter)
1 U.S. grain per gallon .....	17.1 PPM
1 grain per British Imperial gallon.....	14.3 PPM
1 English ( Clark) degree of hardness.....	14.3 PPM
1 French degree of hardness .....	10.0 PPM
1 German degree of hardness.....	17.9 PPM
1 milli-equivalent per liter .....	50.0 PPM
1 milligram per liter .....	1.0 PPM

## Volume Conversions

1 U.S. gallon of water .....	3.785 liters
1 U.S. gallon of water .....	0.1337 cu. ft.
1 U.S gallon of water .....	8.33 pounds (LB)
1 cu. Ft. of water .....	7.48 U.S. gallons
1 cu. Ft. of water .....	6.25 British Imperial gallons
1 cu. Ft. of water .....	28.32 liters
1 cu. Meter of water .....	264 U.S. gallons
1 cu. Meter. of water .....	220 British Imperial gallons
1 cu. Meter. of water .....	1,000 liters
1 cu. Meter. of water .....	35.31 cu. Ft.
1 Boiler Horsepower (HP) .....	4.0 U.S gallons water evaporated/hr.

# C. POOL CAPACITY

## CALCULATION OF POOL CAPACITY:

Before a pool can be properly treated, the pool capacity needs to be determined. The formulas below will give you a guideline to follow. The results of these calculations will be approximate.

## CALCULATION OF AVERAGE DEPTH:

Take the depth at the deep and the depth at the shallow end, divide by two, and this will equal your average depth.

## CAPACITY FORMULAS:

### RECTANGULAR POOLS:

Length x  
Width x  
Average Depth x 7.5 =  
Capacity (gallons)

### CIRCULAR POOLS:

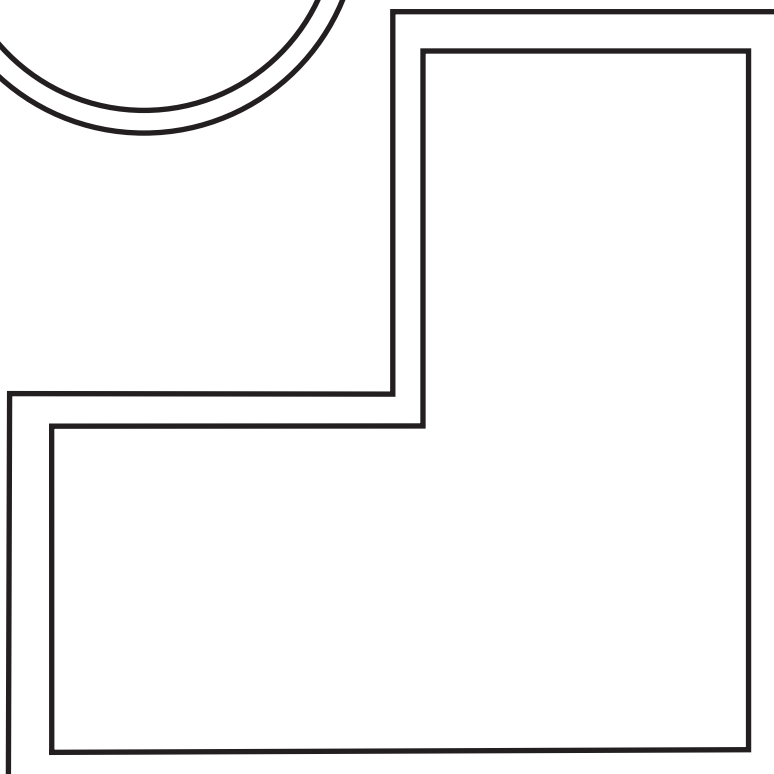
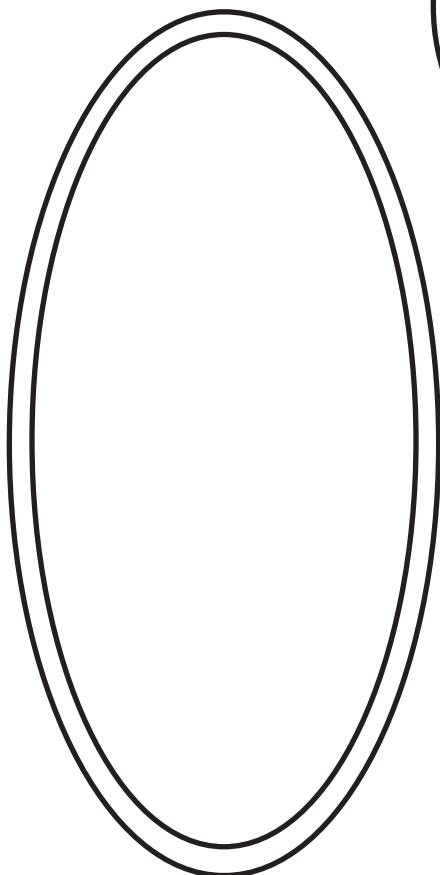
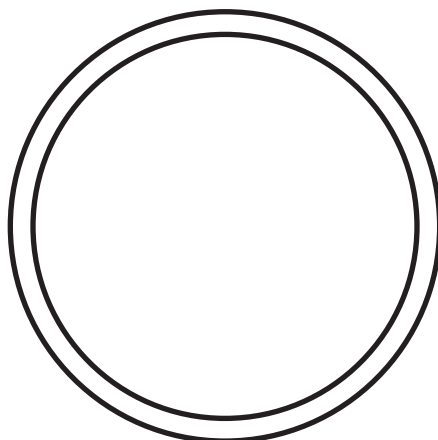
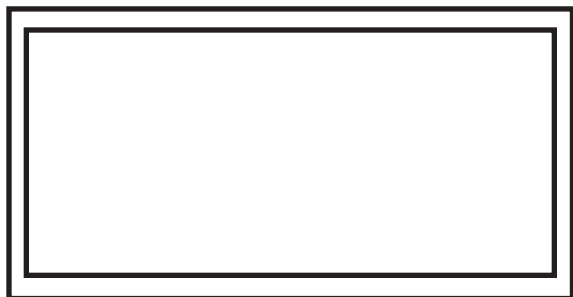
Diameter x  
Diameter x  
Average Depth x 5.9 =  
Capacity (gallons)

### OVAL SHAPED POOLS:

Length x  
Width x  
Average Depth x 5.9 =  
Capacity (gallons)

# IRREGULAR POOLS

To calculate irregular pools, some figuring will be required. If you cannot get the gallon total from the homeowner's pool contractor, you can get an approximate figure by dividing the overall shape into smaller geometric forms- squares, rectangles, circles, or ovals- and figuring the gallon total in each. Then add them together. Below are various examples of pool configurations.



# D. WATER TESTING GUIDELINES AND TECHNIQUES

When it comes to the maintenance of swimming pool and spa water, the service technician wears many hats. Depending on the circumstances, he may be chemist, a lab technician, a biologist, a hydraulic engineer, an analyst, a doctor, or a dispensing pharmacist.

Wearing his chemist's hat, he treats water with various chemicals to sanitize, balance and increase clarity, as well as combat invasion of unwanted plant and animal life. As a lab technician, he performs chemical tests to determine water requirements. He becomes a biologist when he must deal with forms of aquatic life, such as algae. He is a hydraulic engineer when he handles problems with circulation and filtration; an analyst when he determines the proper course of action to take when handling a particular water problem; a doctor when he prescribes a treatment; and pharmacist when he dispenses the treatment.

It should be clear that a good portion of a service technician's job involves recognizing problems, determining cures and administering them. But like any modern-day physician, a good service technician also is concerned with prevention. By anticipating potential problems and dealing with them before they occur, he protects his pool "patients," saves himself work and keeps his customers satisfied. A key ingredient in all of this is water testing.

In this section, we will discuss the theory and purpose of water testing, the various categories of tests that a service technician may need to perform and the general guidelines for sampling water and carrying out accurate, dependable chemical tests. We also will present the options available for performing tests for pH, Total Alkalinity, Acid Demand, and Base Demand.

No one wants to waste money on expansive chemical reagents by performing unnecessary tests, but at the same time, no one wants to invite problems by remaining uninformed about a customer's pool or spa water. So what is the best and most accurate procedure to follow when testing water? What makes a good sample? Is greater accuracy worth additional expenses? We will attempt to answer these questions in our usual manner, presenting the straightforward facts, free of salesman's hype or puffery, so that you can establish the testing procedure that is best for both you and your customers.

## Why Test At All?

Service technicians are charged with responsibility for protecting everything that pool or spa water comes in contact with. That generally boils down to three things: the swimmers or bathers; the equipment; and the pool or spa vessel itself.

To perform this vital protection function, you need to know the condition of the water. If you don't test the water chemically, you're only guessing at that condition.

Back in the old days, when people went for a dip in the swimming hole, Mother Nature pretty much took care of all the water's sanitation and purification needs. But when folks became trapping and re-using water in swimming pools, Mother Nature was taken out of the picture.

Natural bodies of water support a complex network that scientists refer to as an *ecosystem*.

The prefix *eco* comes from the Greek word *oikos*, which means "a dwelling". The branch of biology that studies the relationships between living things and their total environment is therefore known as *ecology*. It takes into account everything that exists in a given ecosystem – living and non-living things alike – and studies how the living things react with one another and with the objects around them.

The ecosystem of a lake or pond includes rocks, sand, and silt that form a natural filter for the water; the plants that produce oxygen and food to support the animal life; and the animals that feed off one another and provide the carbon dioxide and other waste products that support the plant life.

But a pool is not a natural body of water. It has no natural filtration system and no ecosystem of plant and animal life. As a matter of fact, much of our effort in keeping pool water clean and clear is aimed at killing and removing any plants or animals that attempt to gain a foothold in the pool.

To do this, we have to rely on sanitizers, circulation and filtration systems and other chemical and mechanical means to treat the water and we must keep all of these working properly to do their job.

Our sanitizer's effectiveness and the physical soundness of our circulation and filtration system and the pool or spa vessel itself are affected by the chemical content of the water, which must be closely monitored and carefully adjusted.

And the only way to know exactly how the water must be treated is to test it.

## Use the Proper Tools

Every trade has its own set of tools. A carpenter has his hammers and saws; a plumber has his wrenches and pipe cutters; and a service technician has the T-poles, leaf rakes, vacuums, chemicals and other tools he needs to do his job.

Among a service technician's tools should be an accurate test kit. You don't have to go out and buy a \$300,000 spectrophotometer, but you should certainly spend more than \$1.98 to purchase a test kit that will allow you to perform a proper, professional water analysis. Can you make a correct diagnosis or give good advice based on the results you got dumping a few drops of chemical into your customer's pool or spa?

Your livelihood and reputation depend on the quality of your work. In large part, the quality of your work depends on the quality of your tools. If you make a test and get incorrect results and then make a chemical addition to the water based on those results you could damage a customer's equipment – or worse, harm a person.

Besides, you went out and spent \$10,000 or more on a truck just to do your job. Shouldn't you spend more than \$1.98 on a test kit or system that enables you to take care of the water correctly?

## Before You Test

No type of testing is any good at all without first having a good, representative sample of what it is you're testing. That rule applies to political polls, television ratings, and best-seller lists as much as it applies to water testing. Unless your test sample accurately reflects all of the water in the swimming pool, it's not worth the time it takes to draw it.

The purpose of sampling is to collect a portion of material small enough in volume to be conveniently handled while still accurately representing the material that is being tested.

For example, a sample drawn from the surface of the pool when the water has not been circulated will be much different than one taken from two feet below the surface after the pump and filter have been running for a while. Because we are making chemical adjustments based on our sample, it's absolutely vital that it be a good one.

Here are some guidelines to help assure that your water sample represents all of the water in the pool:

- *The water should be circulating before you take your sample* – If the circulation system has been off, turn it on for a few minutes or manually stir the water around before you draw off your sample.
- *Rinse the sample vial 2 or 3 times with the pool water before you take the sample* – This assures that no other water or chemicals used in previous tests have contaminated the sample vial.

*This is one of the most ignored, yet vital, directions which should be found in every test kit instruction. Always rinse and clean the test tubes and sampling equipment thoroughly. This should be done before and after each test. Unclean tubes can result in test container staining and may inadvertently cause false readings if reagent or water remains in a container from a previous test.*

- *Sample the water from 18 inches below the surface* – Because it is exposed to more sunlight and air, water near the surface may be different from water below the surface. Water near the bottom may contain a lot of sediment and other solids.
- *Do not take a water sample from near the return lines* – unless you specifically want to test the water that is being re-introduced into the pool, avoid drawing your sample from near the return lines. Water re-entering has just been filtered and may have been chlorinated or aerated. Therefore, it is different from the rest of the pool water and is not a good representative sample.

- *Water should be room temperature when you test* – Tests should be taken when the water is between 60 and 80 degrees Fahrenheit. Warm water should be allowed to cool; cold water should be allowed to warm before you test.
- *Perform tests as soon as possible after taking the sample* -- don't let the sample stand around for too long before you test it. The water characteristics can actually change if the sample is allowed to stand.
- *Carefully handle samples to be tested later* – If you must carry a sample back to the shop for testing, be sure that the bottle is a clean one and that it is filled to overflowing and capped tightly. Do not allow it to be exposed to excessive temperatures or sunlight while transporting.

The following is a list to keep in mind while conduction water sets. If you ever have trouble determining test results, take your kit along with a water sample to a local pool retailer or service professional for advice.

## **Do's**

1. Always be sure to hold reagent dropper bottles vertically and squeeze gently to obtain uniform drop sizes. Never hold dropper bottles on an angle.
2. Always fill test tubes so the bottom of the water line is precisely on the indicated "fill-to" line.
3. Keep reagent bottles tightly sealed and avoid excessive heat or freezing temperatures.

## **Don'ts**

1. Never leave the test kit where children can find or reach the components within the kit. Remember that safety is top priority.
2. Do not handle reagent tablets and avoid contact with test reagent solutions.
3. Do not store your test kit next to water treatment chemicals. Vapors from these chemicals may destroy instructions and slowly deteriorate components within the test.



## Test Methods

There are three basic methods used in testing pool and spa water, and the name of each method pretty much tells you how you judge the results.

By far, the vast majority of testing in the pool and spa industry is reagent testing. What this means is that you use some sort of color comparison to read your test results. If you use your eyes to judge color you usually need a reference chart, also known as a color comparator. If you use an instrument to make the comparison, it's called photometric testing.

The second type of testing is called turbid metric testing. With this method, you use the relative cloudiness (turbidity) of the water to determine the results. Turbidometric testing can be read both with the eye or with a photometric instrument called a photometer.

The third type is called electrometric testing. This method uses a special electrical probe or electrode to test the water sample and then displays the results on an electronic meter. Many different electrodes have been designed specifically to test different ingredients (or constituents) of water.

All colorimetric and most photometric testing involve the use of one or more chemical reagents. A reagent is any substance used in a reaction for the purpose of detecting, measuring examining or analyzing other substances. High purity and high sensitivity are essential requirements of laboratory reagents. More than 8,000 reagent chemicals are commercially available.

The most common chemical tests in our industry are simple colorimetric test is called a titration. When you do a titration, you put an indicator reagent into a sample and then add another reagent until the sample changes color. By keeping track of the amount of the second reagent needed to cause color change, you can calculate the concentration of the substance you're testing for. Titration is used to test for a large number of substances.

Once you have drawn your water sample and are ready to make your chemical tests, there are a few general guidelines that you should follow. These apply to all tests you will conduct with pool and spa water:

- *Make sure all reagents are fresh* – check with the manufacturer to find out the expected shelf life, or replace reagents annually. Store reagents tightly capped and in a cool, dark place. Sunlight, heat and air can break them down. Make sure that you don't interchange the caps on bottles of liquid reagent.
- *Carefully measure the sample of the water to be tested* – when you fill a test vial with water, the upper surface of the water does not lie perfectly flat. Instead, it's bent upwards at the sides. Scientifically this phenomenon is called a meniscus. You can usually only see it when you put your water in a tall thin vessel like a test tube, a graduated cylinder or a sample cell of a test kit. When you measure a test sample, make sure that the bottom of the meniscus is resting on the manufacturer's fill mark.
- *Don't interchange sample vials* – Use a test vial for only the chemical test it was designed for. This prevents cross-contamination and inaccurate results on your test.

- *Follow the directions* -- if the directions call for adding five drops of a liquid reagent, add five drops: No more, no less. If the test calls for one tablet of dry reagent use only one. If the test tells you to wait 30 seconds for color development, wait 30 seconds, not 20 or 45 or a minute and a half. Don't use one manufacturer's reagent with another's sample vial.
- *Add reagents carefully* – Hold bottles of reagent vertically above the sample vial, and add the reagent slowly. This assures that you get full size drops of reagent directly in the sample and not down the walls of the vial.
- *Mix test sample properly* -- Use the caps provided with the sample vial, not your fingers which could contaminate the sample and produce inaccurate results – not to mention the fact that some reagents are poisonous, hazardous and generally dangerous. Unless the directions specify, never shake a test vial when mixing a sample. Always swirl it in a circular motion or invert it a few times to thoroughly mix.
- *Read results under the right conditions* – unless otherwise instructed, hold the sample vial at eye level, and look right through the middle part of the sample. Read the results against a white background, or place a white card behind the sample vial when reading. Don't wear sunglasses and don't read results in direct sunlight.

When using a color comparator always read test results against a neutral, preferably white, background. If your comparator does not have a diffusion screen or a transparent white screen behind the color standards, it may be necessary to hold a piece of white paper or plastic behind the comparator when reading results. This will neutralize background interferences which can significantly affect test results.

- *Record the results* – It's easy enough to remember test results long enough to make called-for chemical additions, but keeping a written record is really for your own protection. If you are ever called into court, having a written record of tests performed and actions taken can save you both hassle and money.
- *Never put reagents in the pool* – Use sample vials only for making tests. Not only are some reagents hazardous, but it is impossible to get an accurate colorimetric reading by adding reagents to the water in the pool and trying to read them from above.
- *Don't dispose of completed test samples in the pool* – again, the chemicals may be hazardous.
- *Rinse sample vials well after testing* – this ensures that you will get accurate results on your next test.

## Electronic Test Labs

Although they are not designed for service technicians, the most accurate instruments for water testing are complete electronic laboratories, which feature colorimeters and photometers and offer computerized test analysis.

For the most part, electronic test labs perform the same tests that you would normally perform with a test kit, but they measure the water sample and dispense reagents much more precisely, and they can read the color intensity of a sample with much more accuracy than you could with your eyes.

But electronic labs are expensive, and they are not portable. They are really designed for retail, in-store use, where a large numbers of tests must be performed and where impressing your customers is particularly important. The analysis is usually aimed at making a reetail sale of a chemical product, although this certainly does not make the instrument any less valuable as an analytical tool.

With recent advances in electronics, we would not be too surprised if a better operated portable lab for pool-side testing was introduced in the near future. Portable analysis equipment already is on the market. You perform the test, and it analyses the results for you. Can a complete lab test for service technicians be far behind?

## What Tests Are There?

Even though you may normally perform only two or three tests on pool or spa water, there are actually 10 different things that you may need to test for. Because there is more than one way to test for certain things, there are no fewer than 15 different tests available (some involving more than one chemical regiment). The 10 things that you might want to test for include pH, Total alkalinity (TA), sanitizer residual, cyan uric acid concentration, hardness, total dissolved solids (TDS), copper concentration and iron concentration, along with two tests for adjusting pH and total alkalinity – acid demand and base demand.

In the following sections we will examine each of these tests in detail and will discuss the various procedures used to obtain the desired test results. We will conclude with a section on water adjustment and balance.

Proper water maintenance begins with proper, accurate testing. It is what you need to get a complete picture of your customer's pool or spa. If you think of water maintenance as a motion picture, then each test you make is a single frame in that picture. Recording the test results over a period of time will show you exactly how the water in a particular pool or spa behaves. That, in turn will show you how to head off potential problems before they occur.

Pool and spa water maintenance has long been seen a “seat-of-the-pants” operation in which the technician was guided as much by instinct as by science. But when instinct fails, problems can develop. Properly used water testing is a tool that can help you do your job in a complete, professional manner.



Taylor Complete Test Kit



Copper - Ion Test Kit



Phosphate Test Kit



Calcium Hardness Test Kit



Guardex 4 in 1 Test Kit

# E. CARE OF REAGENTS

## HEAT...LIGHT...TIME...FREEZING

Accurate test results require taking proper care of reagents. Using deteriorated or out-of-date reagents may cause inaccurate test results. Let's examine how to recognize and prevent reagent deterioration.

### Heat/Light

As with most perishables, reagents need to be stored under specific conditions.

Exposure to extremes of heat or strong ultraviolet light (sunlight) should be avoided.

Following these helpful storage techniques will help increase the "shelf-life" of our reagents:

- Store out of direct sunlight between 36 and 85 degrees Fahrenheit ( and 29 degrees Celsius)
- Keep reagents in proper case (if appropriate)

### Time

"...how long is the shelf-life of my reagents?" is a frequent question. Unfortunately, there is no definitive answer. Some reagents will last indefinitely while others have a limited shelf-life. Properly recapping the reagent after use with proper storage will assist in prolonging the shelf-life of any reagent. There are certain rules that assist in determining the quality of a given reagent.

1. In general, colored dyes have a shorter shelf-life than colorless reagents.
2. Oxidizing or reducing reagents (often contained in brown bottles) are often prone to shorter shelf-life.
3. In most cases, acids and bases last indefinitely.

### Freezing

In the northern climates, a delivery can be received where the reagents may have frozen. Do they all need to be discarded as useless? Here are some general rules:

1. Dispose of the reagent(s) if the liquid has been forced out of the bottle due to expansion by freezing
2. Thaw the reagent(s) at room temperature ONLY. Never place them in an oven or microwave to defrost.
3. If, after thawing, all of the reagent returns to a clear solution, the reagent can be used. However, if there are particles or suspended solid(s) remaining that will not dissolve, the reagent(s) should be discarded.

Other signs of reagents requiring replacement are a change in color or shade of a color indicator, staining of the plastic bottle, deposit formation (either suspended or at the bottom of the reagent bottle), and crusts of chemicals usually deposited in the area of the bottle cap. Any reagent exhibiting any such signs should be viewed with suspicion.

## PROPER TESTING PROCEDURES

1. **REPRESENTATIVE WATER SAMPLES:** the location in the pool where the water sample is taken has a significant bearing on the representative chemical determinations. Water samples should be taken at least 18” inches below the water surface in areas away from the return line. Insert a clean plastic bottle, bottom side up, to the required depth and turn the bottle top side up to receive the sample of water to be tested.
2. **PROPER SAMPLE VOLUME:** accurate measurements cannot be assured if the sample size is not correct. All water samples, put into a sample container and filled to the marked fill line, display a curvature at the surface of the water. This curvature is called the meniscus and is due to the wetting of the sides of the container by the sample water. Always fill the container such that the low point of the meniscus rests on the fill mark. Have the fill line at eye level when filling the sample container.
3. **MATCH YOUR COLORS:** Matching colors in colorimetric determinations is done by holding the object that is to be compared up to northern light.
4. **SWIRL...SWIRL...SWIRL...:** Proper results depend on either color comparisons or detection of a color change (endpoint). For this to happen, reagents must be thoroughly mixed in the water sample. When titrating, the sample must be swirled after each drop of titrant is added to see if the color change is permanent (the end point has been reached).
5. **CORRECT DROP SIZE:** When adding any reagent drop-wise to a water sample, hold the dropper bottle vertically (straight up and down). Holding the bottle at an angle while adding reagent may distort the drop size and lead to inaccurate results. Static electricity sometimes builds up around the dropper tip, reducing the drop size and resulting in a false high reading. To correct this problem, simply wipe around the dropper tip with a clean damp cotton cloth or paper towel to remove the static electricity.
6. **PREPARE FOR THE NEXT TEST:** After testing, flush out sample cells with tap or fresh sample water to avoid any residual from interfering or contaminating the next test. Additionally, colored solutions remaining in the test cell may stain the sides of the cell, compromising color interpretation. Finally, replace reagent bottle caps and securely tighten to avoid external contamination.
7. **ALWAYS FOLLOW MANUFACTURER’S INSTRUCTIONS.**
8. **USE THE REAGENTS MEANT FOR THE KIT:** Never interchange reagents from other kits or other manufacturers.

9. BE SURE TO USE THE CORRECT AMOUNT OF REAGENT REQUIRED FOR THE TEST
10. TEST WATER IMMEDIATELY AFTER SAMPLING: If the sample sits for as little as one minute after removal, values may decrease – especially when testing sanitizer levels.
11. ALWAYS WAIT ONE COMPLETE FILTRATION CYCLE AFTER CHEMICAL TREATMENT TO TEST WATER.
12. ALWAYS USE PLASTIC CONTAINER TO COLLECT WATER SAMPLE: Glass containers might break.



# F. POOL CHEMISTRY

	Normal Range	What can happen if it's too high	To decrease	What can happen if it's too low	To increase
<b>Chlorine</b>	1.0 to 5.0 PPM	Health hazard (swimming should not be permitted)	Wait; Chlorine will dissipate quickly	Health hazard. Algae and bacteria may grow.	Add Chlorine
<b>pH</b>	7.2 to 7.8 preferably on the lower side	Eye irritation; Cloudy water; Scale may form; Walls may stain; Cl less effective; copper ay fall out of solution	Do an acid demand test, then add acid	Eye irritation. Water becomes corrosive and can damage pool equipment.	Correct TA first. Wait for pH to drift up. Do base demand test & add soda ash only after TA is correct and pH is still low
<b>Total Alkalinity (TA)</b> <b>(correct alkalinity before adjusting pH)</b>	80 to 100 PPM.	pH constantly drifts higher; Cloudy water	Add acid to bring pH down to 7.2 Check pH and repeat daily.	pH changes quickly. Water etches plaster and corrodes metals	Add baking soda
<b>Calcium Hardness (Ca)</b>	150 to 300 PPM.	Cloudy water; Scale may form on pool walls and plumbing; Can clog heater and filter.	Partially drain and refill pool.* Check Ca in source water first,	Damages pool by pulling calcium from walls making pool walls rough.	Add calcium chloride.
<b>Total Dissolved Solids (TDS)</b>	300 to 1,500 PPM.	Cloudy water; Particles (including copper) fall out of solution; Cl less effective	Partially drain and refill pool*	Ion Current may be too low to put enough copper into the water	Add salt only if ion current and Cu are low. Never add salt as cure for worn out electrodes.
<b>Copper (Cu)</b>	.20 to .30 PPM,	Cu can fall out of solution and cause staining or light green water	Turn ionizer to lowest setting & wait for Cu to drop. If Cu is above 0.4, partially drain & refill pool or add approved stain preventative.	Algae and bacteria may grow	Adjust ionizer to a higher setting. Treat algae if necessary.
<b>Cyanuric Acid (stabilizer)</b>	35 to 50 PPM. (100 PM max)	Health hazard; Reduces chlorine and oxidizer effectiveness	Partially drain and refill pool	Ineffective in stabilizing chlorine	For outdoor pools using add cyanuric acid

NOTE: CHLORINE AND CYANURIC ACID ARE NOT REQUIRED IN A *Clearwater Enviro Tech* RESIDENTIAL POOL.

A maximum of 50 PPM Cyanuric Acid is recommended with a *Clearwater Enviro* system. It is better to not have any cyanuric acid in pools not using chlorine

Abbreviation PPM stands for: Parts Per Million & Equates to milligrams per liter. Abbreviation ppb stands for parts per billion.

\*Partially drain means 1/3 to 1/2 and repeat if necessary. For high concentrations, it is better to drain the pool completely. Follow precautions for areas with high water tables or hot, dry climates.



# G. pH

## Definition

A scale of measurement, pH, was invented to measure the acidity of water in the brewing of beer in the early 1900's. "pH" stands for "potens hydrogen" – Latin for "hydrogen power" – as acidity is caused by a predominance of the chemical species "H.P." of hydrogen ions.

pH is measured on a scale from 0-14, with a pH of 7 being neutral. Below 7, the water is acidic, and above the water is basic (or alkaline). The pH of 6 is 10 times more acidic than a pH of 7, and a pH of 11 is 10,000 times more acidic than a pH of 7! Note that the pH range recommended for pool/spa water is slightly alkaline, which assists bather comfort, as the pH of the human eye is about 7.5!

Technically speaking, pH is based on the concentration of the hydrogen ion (H<sup>+</sup>).

## Importance of pH

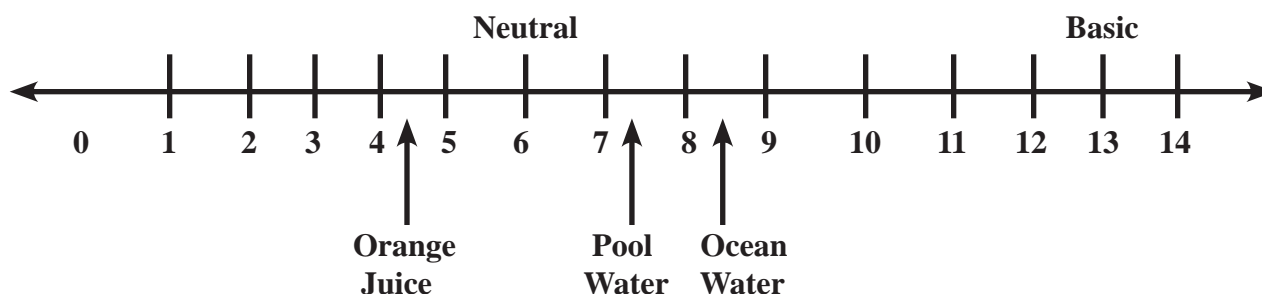
pH is the most important aspect of water chemistry. The control of pH is important because it affects bather comfort, sanitizer activity and overall water balance.

An improper pH can lead to cloudy water, algae growth and can damage or even destroy pool surfaces and equipment. Eye irritation results when pH of the water is different from the eye's natural pH of approximately 7.5.

Orange juice has an acidic pH of 4.2. Ocean water is basic with a pH of about 8.0.

**Corrosive**

**Scale Forming**



## RECOMMENDED RANGE

**Clearwater Enviro Technologies** recommends a pH of 7.2 to 7.6. This is THE MOST IMPORTANT TEST to monitor. Try to keep the pH as low as possible (for water clarity) without dropping below 7.0. a pH of 7.2 to 7.4 gives the water a clear look while providing a safety zone to prevent low pH. Since pH normally tends to drift upward, in concrete pools, the slightly lower starting point (7.2 – 7.4) will usually allow the pool to go an entire week before more acid is required and still not exceed an accepted maximum pH level of 7.6.

## TESTING OF pH

**METHOD:** pH is a colorimetric measurement using a colored indicator designed for a specific range. The most commonly used method is by **phenol red** (6.8 - 8.4).

This organic dye's proper name is **phenolsulfonephthalein**. If you try to pronounce it or spell it, you can easily see why it's called phenol red! Its color characteristics are extremely sensitive to a narrow range of acid and base. Even though the entire pH scale ranges from 0 to 14, the sensitivity range of phenol red is only from about 6.89 to 8.2. It is most accurate right in the middle of its range – around 7.5. That's one of the biggest reasons that's it's used so widely in our industry.

Phenol red is a bright to dark red, crystalline powder, although it is most commonly sold in liquid solution or in tablet form. The phenol red solution is dark red. To test the pH of pool water, you normally add five drops of phenol red solution to the test sample, which may vary from 1/5 ounce (6 milliliters) to one ounce (30 milliliters) depending on the manufacturer of the test kit. **Clearwater Enviro Technologies** recommends the use of **Taylor** test kits when out on service calls.

At the low end of the test, the color is almost orange. As the pH increases, the color turns red and becomes almost purple as the pH nears 8.2. The color develops within a couple of seconds. The color comparator that accompanies a phenol red pH test is usually divided into segments of .2 pH units.

Because some sanitizers also have the ability to bleach color, high sanitizer levels in a pool water sample can change the color of a phenol red test and produce an inaccurate reading. High chlorine or bromine residuals can actually combine with the phenol red to produce entirely different chemical compounds – **chlorphenol red** and **bromphenol blue** – which can cause the test sample to turn deep purple and become useless. Therefore, many test kit manufacturers include a bottle of neutralizer to be added to the test sample before the phenol red, or they include a neutralizer in with the phenol red solution.

With the Taylor test kit, high levels of chlorine (7 – 10 PPM) will completely convert phenol red into a new pH indicator (chlorphenol red). This new indicator is a dark purple when the water is alkaline. Unfortunately, some pool operators mistake the purple color for dark red and think the pool water is very alkaline and wrongly add acid to the pool.

When a sanitizer level is not extreme, only some of the phenol red may convert to chlorphenol red. However, purple + orange (for example pH 7.4) = red. This error is more subtle as no purple color is observed and the operator does not suspect that a false high pH reading has been produced. Some operators neutralize the sanitizer first by adding a drop of chlorine neutralizer (e.g. sodium thiosulfate). However, thiosulfate solutions have a high pH and if heavily used, may cause a false higher sample pH.

Always be careful when reading the pH test. Since most test kits will only indicate a maximum pH of 8.0, the same is true for the other end of the scale at 7.0. a pH below 7.0 will register as 7.0, and recording – 7.0 will indicate this condition as well.

## **HIGH pH**

A high pH is the worst thing that can happen to a pool owner. High pH affects the water's ability to hold solids in solution. Water gets cloudy when solids fall out of solution or are suspended in the water. Scale can form on walls when calcium falls out of solution. Copper, iron, and other metals can stain the pool if dropped from solution, effectively killing algae. Copper ions fall out of the solution, thus giving a low read out on the test kit. Chlorine also becomes less effective with a high pH level (see chart in Chlorine Section). The sanitizing and oxidizing power of chlorine is only 22% effective with a pH of 8.0.

## **LOW pH**

If the pH becomes too low, it can etch calcium from the walls of plaster or gunite pools. It will cause corrosion of pool equipment and staining. Low pH will damage and discolor the liners of vinyl and above-ground pools. Swimmers will report eye irritation.

## **FACTORS OF pH CHANGE**

What can affect the pH? Will it go up or down? Just about everything affects the pH level in a pool or spa. The pool's finish is a big factor. A new concrete pool will generally have a big pH increase during the first month or so, as the pool is still curing. An older pool's pH may still rise, but not as fast as a new one.

The sanitizer used affects the pH greatly. While copper and silver have little effect, the type of chlorine used can influence the pH. Dichlor, trichlor, gas chlorine all lower pH, while liquid chlorine, calcium hypochlorite raise it.

The rain affects pH. An acid rain will lower it somewhat, while other types of rain generally raise it. Heavy bather loads may actually lower the pH, but suntan oil on bathers may raise it. In spas, due to the nature of small amounts of water, the pH will drastically change more often than in pools because the bather load is in direct contact with virtually all of the water. Some pool techs say a pool vacuum will raise the pH a bit. Fresh make up water will affect the pH also.

## HOW OFTEN TO TEST

In residential pools, the pH should be tested once a week. In hot, rainy seasons, it should be tested at least twice a week.

Commercial pools need to be tested at least once a day because of heavy swimmer usage. The pool's pH level is consistently being changed by the small amount of chlorine required in the commercial pools while used with the **Clearwater Ionizer**.

## HOW TO ADJUST

In adjusting the pH, it is important to use an acid demand test instead of guessing. The effectiveness of chemicals to adjust pH depends on total alkalinity and can vary widely. Many pool owners use a simple test kit that tests only pH and chlorine. For proper pool maintenance it is also important to be able to tests total alkalinity and acid demand.

If the customer questions the necessity of a more “expensive” test kit, remind him that after spending in excess of \$10,000 for his pool, wouldn't it make sense to spend an extra \$15 on a good test kit to protect his investment. Remind him of the famous transmission commercial that concludes “you can pay me now, or you can pay me later...”

The necessity for a test kit that can determine acid demand and total alkalinity is shown by this example: two 20,000 gallon pools could both have a pH of 7.6 and one could require a gallon of acid and the other may only require a cup of acid to lower the pH to 7.2. The difference is that the first pool had a high total alkalinity and the second had a low total alkalinity.

In pools that are treated with chlorine gas, a lot will have to be added. Don't confuse baking soda ash and sodium bicarbonate. Sodium bicarbonate is ordinary “Arm and Hammer” baking soda available at any food store. Soda ash is only available in pool stores. Baking soda is used to raise total alkalinity (see next chapter).

## DECREASING THE pH

To decrease the pH, first do an acid demand test and then add muriatic acid (liquid) or sodium bisulfate (dry acid). It is very inexpensive and available at all pool stores and many hardware and home improvement centers like *Home Depot or Builder's Square*.

Muriatic acid may range in color from a clear to yellow, and has a shelf life of up to 6 months. Muriatic acid is dangerous stuff, so you want to keep it away from children.

The dry acid (sodium bisulfate) is generally 4-5 times as expensive as muriatic acid, and is much slower in lowering the pH.

Muriatic acid is heavier than water and will go straight to the bottom and could damage a pool. Always add acid to the deep end of the pool away from the sides. Try to add acid in front of the return lines to spread it out quicker.

The safest way to add acid is to dilute the acid in a bucket of water and then add the diluted mixture into the pool. Never add water to acid; add acid to the water.

If a customer was using dichlor or trichlor chlorine tablets, and discontinues the use of these products when he purchases a **Clearwater Ionizer**, he may need to use a little more acid than before. This is because those types of chlorine sources lower the pH somewhat.

# H. TOTAL ALKALINITY

## DEFINITION

In simple terms, total alkalinity is the amount of “basic” (non-acid) materials in a water supply which enables the water to resist abrupt changes in pH. It is the reserve of buffering agents that react with and neutralize contaminating acids and bases to maintain a chemical balance. A buffer is a chemical that resists change upon the addition of acids or bases. In water that contains no buffering ability, pH can wander dramatically. This is called pH bounce - a rapid fluctuation of pH levels with the addition of small amounts of acid, base or other pH altering agents.

## IMPORTANCE

It is very important to adjust the total alkalinity simply because it directly reflects the waters pH level (see previous chapter).

In balancing pools, the total alkalinity should be balanced FIRST, and then the pH. Many people overlook this fact.

## RECOMMENDED RANGE

The recommended range of total alkalinity with the **Clearwater Ionizer** is 80-100 PPM. This is because the sanitizer you are using (copper ions) is basically neutral or just slightly alkaline. In pools where the sanitizer is acidic, like gas chlorine or trichlor, a higher total alkalinity should be used.

## TESTING OF TOTAL ALKALINITY

The process of testing total alkalinity is called a titration. What this means is that you put an indicator reagent into a sample and then add another reagent until the sample changes color. By keeping track of the amount of the second reagent needed to cause the color change, you can calculate the concentration of the substance you’re testing for. Multiplying the number of drops by a number supplied by the test kit manufacturer (usually 10) will equal the total alkalinity in PPM.

It’s probably clear to you by now that pH and total alkalinity are related. It’s not possible to change one without having an effect on the other.

Now you may be asking, if total alkalinity reduces acid’s ability to lower pH, why do we want it in our pool water at all?

Total alkalinity, as we stated before, is the “buffering capacity of water or its ability to resist change in pH”. Drug manufacturers add buffering agents to aspirin to prevent the acid in it from damaging the lining of your stomach. Similarly, by preventing or slowing down changes in pH, total alkalinity protects the pool plaster and equipment from damage.

The bottom line is, TOTAL ALKALINITY is the key to water balance.

We realize that this is probably contrary to what you learned or may be doing, but if you will just try adjusting total alkalinity first, you will be amazed at how close the pH is to being correct and how easy it will be to keep the pH where it should be.

## **HIGH TOTAL ALKALINITY**

If the total alkalinity is too high, even additions of large amounts of muriatic acid will have little effect on pH. If the total alkalinity remains high for very long, it will cause dissolved calcium in the water to begin to form scale on pool walls and equipment. Cloudy water will develop and the pH becomes resistant to change and tends to stay in the high range. Staining can also take place.

## **LOW TOTAL ALKALINITY**

If the total alkalinity is too low, just about anything you add to the water will have a dramatic effect on the pH. If the total alkalinity remains low for very long, the water will begin to dissolve the metallic parts of the pool equipment.

The pH will be subject to rapid change from rain, swimmers and chemicals. Pool owners, who are constantly chasing pH going up or down, usually have a low total alkalinity problem.

## **FACTORS OF TOTAL ALKALINITY**

Factors effecting total alkalinity are those similar to pH. Anything acid or alkaline in the water will affect the total alkalinity.

## **HOW OFTEN TO TEST**

The total alkalinity should be tested on residential pools and at least once a month. Commercial pools should be tested at least once a week, or even daily. The more often total alkalinity is tested, the easier the pH will be maintained.

## HOW TO ADJUST

Of all the factors a pool owner must know, this is the trickiest of them all. How do I adjust total alkalinity and pH at the same time so they are both in range?

In the pool and spa industry, there are four chemicals commonly used to adjust pH and total alkalinity at the same time. Muriatic acid, dry acid (sodium bisulfate), soda ash (sodium carbonate), and baking soda (sodium bicarbonate).

### INCREASING THE TOTAL ALKALINITY

It is important to note that increasing the total alkalinity will affect the pH as well. To increase the total alkalinity with the smallest effect on pH, use baking soda (sodium bicarbonate). It has a pH of 8.3. When added to water, it comes apart into one sodium ion ( $\text{Na}^+$ ) and bicarbonate ion ( $\text{HCO}_3^-$ ), which combines with a hydrogen ion to form carbonic acid. Baking soda uses up one hydrogen ion in the process, which increases pH only slightly. Approximately 20 ounces of baking soda in a 10,000 gallon pool (about 1 ½ pounds) will raise the total alkalinity about 10 PPM. In spas, one ounce will do the job in a 500 gallon spa.

To raise pH and total alkalinity, use soda ash. The pH of soda ash is about 13. When added to water, it comes apart into two sodium ions ( $2\text{Na}^+$ ) and a carbonate ion ( $\text{CO}_3^-$ ). The carbonate ion combines with one hydrogen ion ( $\text{H}^+$ ) to form a carbonate acid ( $\text{H}_2\text{CO}_3$ ). Soda ash thus uses up two hydrogen ions in the process, and increases the pH.

### DECREASING THE TOTAL ALKALINITY

To lower the total alkalinity when the pH is high, do an acid demand test and lower the pH to 7.2. With high total alkalinity, the pH will bounce up the next day. Continue the daily addition of acid until the total alkalinity drops to the 80-100 PPM range. It may take a few days of repeating this process before the total alkalinity reaches the proper range. Adding larger amounts of acid that lowers the pH below 7.2 is not recommended.

Either muriatic acid or sodium bisulfate may be used to lower total alkalinity. As mentioned in the pH section, muriatic acid is much less expensive and is a stronger form on acid. One quart of muriatic acid is equal to 2 ½ pounds of dry acid.

In general, 25 ounces of muriatic acid or two pounds of dry acid in a 10,000 gallon pool will decrease total alkalinity by approximately 10 PPM.

You should never add more than one quart of muriatic acid or 2 ½ pounds of dry acid per 10,000 gallons per day. In spas you should not add more than 1 ½ ounces of acid at a time, all though the rapid turnover of spa water does not permit you to add acid as often as once every 30 minutes. When you add to a spa it should be diluted or pre-dissolved before you add it.



If you stand in one spot and pour muriatic acid into the pool you will lower total alkalinity dramatically with little effect on pH. If you “walk” it around the pool, you will lower both pH and total alkalinity. The reason for this is that when you concentrate the acid in a small area, the pH within that area drops less than 5.5.

And it that pH, carbonates ( $\text{CO}_3$ ) take a shortcut around several chemical reactions and are converted directly into carbon dioxide ( $\text{CO}_2$ ), which is a gas, if you ever notice gas bubbles or vapor forming near where you add acid, that's the  $\text{CO}_2$ .

## FALSE READINGS

Determining the exact total alkalinity reading on a standard test is often challenged by pool experts. Some claim certain manufacturers of total alkalinity tests are inaccurate,

Some claim that when cyanuric acid is present in the pool, it will cause an error in the test for total alkalinity. They say to correct the error, decrease the total alkalinity reading by 1/3 of the cyanuric acid reading. For example, if the cyanuric acid test indicated 90 PPM. And the total alkalinity test indicated 100 PPM. The reading should be 70 PPM. ( $100 - 1/3$  of 90 or  $100 - 30$ ).

# I. CALCIUM HARDNESS

## DEFINITION

The calcium hardness of water is a measurement of dissolved minerals in water, principally calcium and to a lesser extent magnesium. The term “hardness” originally referred to water’s ability to prevent soap from sudsing. Water that resisted sudsing became known as hard water, and water that promoted sudsing became known as soft water.

As any sailor can tell you, if you try to take a shower in salt water, your soap doesn’t suds very well. It still cleans, it just won’t make suds.

If you’ve ever taken a shower in a home where they have a “Water softener”, your skin still feels slippery even though you’ve rinsed off all of the soap.

Years ago scientists set out to discover just what it was that made some water hard and some soft. They found out that certain dissolved mineral salts react with the soap to form a precipitate, which prevents the soap from sudsing. These mineral salts could be calcium, magnesium, aluminum, iron, manganese hardness, aluminum hardness, iron hardness, and so on.

By far the two most common salts – and the ones normally present in the highest concentrations – are calcium and magnesium. In fact, about 70 to 75% of the hardness in tap water is due to calcium, and 20 – 25% is due to magnesium. In pool water – especially if it has been in the pool for any length of time – 90 to 95% of the hardness is due to calcium.

The term “hardness” simply describes a characteristic of water that represents the total concentration of calcium and magnesium ions.

Where does all this hardness come from? It comes from the soil and the rocks that the water flows over on its way from its source to you. As the water flows, it erodes and dissolves the soil and rocks, picking up calcium and magnesium salts of the bicarbonates, carbonates, chlorides, hydroxides, nitrates, silicates and sulfates. These dissolved salts make the water “hard”.

We get our water from three basic sources:

1. Ground water from a well
2. Surface water from a reservoir or lake
3. Tap water from a water-treatment plant

The source of the water is important, because the hardness can vary rather dramatically from source to source.

Limestone is the basic source for water hardness in the United States. Most areas of the country have relatively hard water, although some parts – like Atlantic and Gulf coasts and the Pacific Northwest have low levels of hardness in much of their water supply. Some are actually lower than 60 PPM.

Some municipal water plants treat their water supplies to reduce hardness. So tap water may have a much different hardness level than ground or surface water.

Generally, a hardness level of more than 180 PPM is considered “very hard”; 120-180 PPM is considered “hard”; 60-120 PPM is considered “moderately hard”; and below 60 PPM is considered “soft”.

In the pool and spa industry, the word “soft” could also mean “corrosive”, “aggressive” or “hungry”.

## **RECOMMENDED RANGE**

We recommend a calcium hardness range to be between 150 – 300 PPM any reading below or above that should be corrected.

## **IMPORTANCE OF CALCIUM HARDNESS**

There are numerous reasons for testing calcium hardness. The most important is to evaluate the pool water’s aggressive or saturated nature. Water is naturally aggressive and is known as the “universal solvent”. In pool water it is important to evaluate the level of calcium hardness since water has a natural tendency to dissolve certain minerals that are a component of the pool surfaces. If the water contains too many minerals it may become saturated. As a result, the calcium will begin to fall out of the water and settle around the pool, leaving noticeable crusty, white deposits. These deposits are called scale formations and can be seen on pool parts and walls. Scale formations can clog filters, heater and plumbing fixtures which lead to etching or pitting in the plaster. Vinyl and plaster pools with inadequate hardness levels are susceptible to corrosion of metal parts in the pool or heat exchange systems.

Fortunately, water does not have a saturation point where it no longer is aggressive and will not deposit scale on pool surfaces. This condition is why every pool owner needs to provide maximum protection to the pool surface and its parts. The term “water balance” can only be obtained when calcium hardness, pH and total alkalinity (described in the two previous chapters) are all at the recommended levels.

## **HIGH CALCIUM HARDNESS**

Water that contains high levels of calcium and magnesium salts is called hard water because it consumes soap and is “hard to form suds”. These minerals combine with soap to form a grey insoluble curd-like substance and cause problems in laundry use. Hard water can stain dishes and clothes.

In the pool and spa industry, problems of high calcium hardness are serious. High levels of calcium may exceed the water's ability to hold it in solution. If undissolved, it can make the water cloudy. Calcium can cause damaging scale formations on pool walls, heater elements, and the interior of pipes. Very high scale can form on the **Clearwater** electrodes, requiring frequent cleaning.

Normally, calcium hardness steadily increases in a pool since evaporation leaves the calcium behind. The constant addition of calcium hypochlorite (granular chlorine), which is about 1/3 calcium, will raise the calcium hardness level. Fresh water (which naturally contains calcium) will also raise the calcium level.

Other problems, besides cloudy water, will be plugged filters and reduced circulation.

## **LOW CALCIUM HARDNESS**

Water that contains low calcium hardness is called "soft". This will cause the water to etch calcium from the walls of a plastered pool. There will be pitting of concrete, dissolving of grout and pitting of pool decks.

In the laundry industry, the goal is to remove calcium and magnesium from the water. In the pool industry, magnesium does not form scale and the interest is focused only on calcium. For both water and some industrial applications, water is "softened" before use, employing water softeners that remove all of these minerals.

Never fill a pool with water that has been treated with a water softener. You can destroy a pool if it is filled completely with "softened" water. The water will pull calcium out of the pool walls. Chances are the water will be cloudy all the time.

## **FACTORS OF CALCIUM HARDNESS**

As mentioned in earlier sections of this chapter, the water's source, and anything being added to the water that has calcium in it will affect the amount of calcium hardness in the water. The pH and total alkalinity readings greatly affect the readings in concrete pools.

## **HOW OFTEN TO TEST**

The calcium hardness level should be tested once a year, unless previous problems exist.

## HOW TO ADJUST

The basic method used to test water hardness is with a colorimetric test involving a titration. In the calcium hardness test, you first add a buffer solution to the water sample. The solution contains an organic dye and a buffer that increases the pH of the sample to around 10.0, which is where the test works best. The dye reacts with calcium and magnesium ions to produce a red color.

Then you titrate the sample using a chemical reagent known as ethylenedramine tetraccetic acid. We commonly call it EDTA (I wonder why?!) As the EDTA is added, it combines with all the free calcium and magnesium ions. After it has combined with all of the calcium and magnesium ions in the sample, it combines with the magnesium ions in the dye, causing the color to change from red to blue.

The number of drops of EDTA required to cause the color change is then multiplied by a factor provided by the manufacturer (generally 10) and this will tell you the hardness – expressed as PPM of calcium carbonate.

## TO INCREASE CALCIUM HARDNESS

To increase calcium hardness, add calcium chloride. One and one quarter pounds per 10,000 gallons will increase the calcium hardness by 10 PPM.

Never add more than 10 pounds per day per 10,000 gallons of water (1 Kg/10m cubed). Calcium chloride will cause excessive and long-lasting cloudiness if added in too great a quantity.

It is important not to confuse calcium chloride with calcium carbonate. Although the test expresses calcium levels in PPM calcium carbonate, calcium carbonate does not dissolve well in water and is not used in swimming pool maintenance.

## TO DECREASE CALCIUM HARDNESS

To decrease calcium hardness, partially drain and refill the pool with fresh water. Also balance the water again after replacing large amounts of water. Always use caution when training pools in hot, dry areas, or areas of a high water table. Before filling the pool with make-up water, test the calcium hardness of that water. If the make-up of that water is high in calcium hardness you may be wasting your time and water.

It is very important that the calcium hardness be in the correct range to protect the pool and to have clear water. Many pool owners do not want to drain their pool. They have to be convinced of the importance of a proper calcium level. Show them this book, if needed.

The **Clearwater Ionizer** will work regardless of the calcium level, but it is important that the pool water is balanced to limit scaling and staining.

Make sure the customer understands that you are not recommending that part of the water be drained because the **Clearwater Ionizer** is being installed. He may think “well, if I have to do all that I had rather keep using chlorine”. If he keeps using chlorine, it is even more important that he drains part of the water when the calcium is too high. The **Clearwater** system can work with high calcium hardness better than chlorine can, but high calcium hardness is less than ideal for either treatment and is damaging to the pool.

## **FALSE READINGS**

The most common error in a calcium hardness test is called a fading endpoint. Here, instead of obtaining a clear end point, some color change is observed but soon reverts back to the original color. This usually occurs due to interference from the copper-ions already in the water. This will cause the test to develop a purple color rather than blue. To alleviate this from happening, add two drops of the titrant to the water sample first and then conduct the test as usual. The titrant “ties up” the interfering soluble metals and the test can then be completed with a sharp, distinct endpoint. Count the number of drops of titrant used to reach the endpoint and add two drops initially added to obtain the total number of drops used.

Besides copper-ions, iron, cobalt and nickel can interfere with the test.

# J. TOTAL DISSOLVED SOLIDS

## DEFINITION

Total dissolved solids, or commonly referred to as “TDS” is the sum total of all the dissolved materials in the water, some of its chlorides, algaecides, soda ash, baking soda, and even tile cleaner and body oils.

In short, it’s everything that you’ve put in the water – or that occurred naturally in the water that stayed there long enough to dissolve.

Distilled water is an example of a solution that contains no dissolved solids. Sea water, on the other hand, contains a vast amount of total dissolved solids.

## IMPORTANCE

TDS may well be one of the most misunderstood factors in the entire field of pool and spa water chemistry. It is misunderstood because no one knows exactly what its effect is going to be in any particular body of water.

For example, high TDS can result in corrosion of metal equipment and accessories even though the water is balanced, but that doesn’t always happen. High TDS can cause eye and skin irritation, even though the pH is right and there are no chloramines in the water. But that doesn’t always happen. High TDS can allow algae to grow in the pool even if there is plenty of copper-ions or a 3 PPM of chlorine residual. But that, too, doesn’t always happen.

At low levels, TDS does not present a problem. In fact, a certain amount of TDS is necessary for proper water balance. Hardness and total alkalinity are both part of TDS.

But at high levels, TDS can begin causing trouble. With the **Clearwater Ionization System**, we recommend the level to be below 2,000. The NSPI (National Spa & Pool Institute) recommends an ideal TDS level of 1,000 - 2,000.

The main reason high TDS can cause problems is that there are a lot of dissolved substances in the water, and it will interfere with the normal workings of sanitizers. They may do this by forming a chemical “shield” around bacteria, algae and other substances normally attacked by the copper-ions or chlorine.

Another theory of TDS problems is that they may present “roadblocks” in the path of sanitizer molecules, preventing them from freely circulating throughout the water to do their work.

The TDS level is crucial when using the **Clearwater** system. The water must be conductive enough in order for our systems to work. The **Clearwater** system works by running a small electric current between the two-copper/silver electrodes. This small current causes the copper and silver ions to dissolve into the water. Pure, distilled water has a TDS of zero and is electrically non-conductive.

## RECOMMENDED RANGE

THE RECOMMENDED RANGE OF THE TDS level with the Clearwater system is between 500 and 1,500 ppm. If the range is below 500 ppm, the units cannot produce ions at 100% capacity. As a rule of thumb, the RC-50 units can obtain a maximum readout very similar to the TDS level – for example if the TDS is 400, the highest the ionizer will go is about 400 mA. The R-20 and R-40 units will give a slightly higher reading on very low TDS levels, but they also require a TDS of about 500 to reach full capacity.

## TESTING OF TDS

Around 40 years ago, scientists developed a standard for relating the conductivity of water to the amount of impurities dissolved in it. This led to the development of a TDS meter - an electrometric device that passes a small current between two electrodes immersed in water and separated by a specific distance. The meter measures the current passing between the electrodes and uses that to determine the water's conductivity – an indication of TDS. Although the meter is calibrated to read TDS in parts per million, it actually is measuring conductivity over the fixed distance that separates the electrodes – expressed as *micromhos per centimeter*. The standard unit of electrical conductance is the mho. (Pronounced like Moe, of the three stooges!). A micromho is one millionth of a mho. Another name for the mho is the *Siemen* (pronounced see-men) and TDS meters would then be calibrated in *micro* Siemens per centimeter.

TDS meters are available in either analog models (with a pointer to indicate TDS on a scale) or digital models which read out the TDS on an LCD calculator. A portable TDS meter, that can fit in a pocket or belt strap can vary in price from around \$40 to \$150. They seldom break down and usually only require an annual battery replacement. They do require occasional calibrations, but the more expensive meters often contain a built in calibration test.

There are two major types of TDS meters. With one, you immerse the probe directly in the pool water. With the other, you fill a sample cell on the meter with water drawn from the pool or spa. Both meters give you a readout of TDS in parts per million.

The water conductivity is affected by temperature, but most TDS meters are temperature compensated, either manually or automatically, depending on manufacturer and price.

## HIGH TDS

Just like a glass of iced tea that can hold only so much sugar (a dissolved solid), the pool water can only hold so much dissolved solids in solution; the rest falls out. The amount held in solution depends on the pH, total alkalinity and overall water balance.

The solids that fall out of solution may stay in suspension, causing cloudy water, or may stick to the pool walls and form scale or stains. High TDS can also cause scaling on metal pool fixtures such as ladders, lights and heaters. With high TDS levels, chances are you are using a lot of oxidizer (chlorine) and experiencing cloudy water.



Generally, TDS is not a problem until it gets well over 2,000 ppm, and this usually takes several years. Anytime something is added to the water, the TDS will increase (see chart J-3 this section)

## HOW OFTEN TO TEST

The TDS level should be tested once a year. As a dealer, you should test the TDS level before installation. If it is too high, corrections should be taken to prevent call-backs. Once corrected and retested, the TDS level should be checked on a once a year basis. We recommend that you offer a once-a-year “tune up” for the customer. Charge a normal service call charge for this feature and test other items like calcium hardness, phosphates, the ionizer itself, etc.

## INCREASING THE TDS

Normally, you won't need to increase the TDS level in the pool. Low TDS is desirable. The only time you would need to increase the TDS level is when the digital readout shows less than 100 milliamps on the ionizer for each 10,000 gallons of water. For example, if the pool is 20,000 gallons and the milliamp reading is only 120, the 120 milliamp reading might not be enough to put the proper amount of copper and silver ions into the water. Thus, the TDS level will need to be increased somewhat. If you have an R-20 or R-40 unit, wait at least 2 weeks to see if the TDS needs to be raised. These models do not have a digital readout, so manual readout of the TDS should be taken before installing the unit.

For every 10,000 gallons of water, you will need a milliamp reading of 100. So even at a TDS level of 100 ppm, the milliamp reading should be enough to handle a 10,000 gallon pool. You rarely will find a TDS level that low, but if you do, you can simply add some salt.

**One pound of regular table salt will raise the TDS of 10,000 gallons of water (125 grams per 10 cubic meters) by approximately 12 ppm.**

Never increase the TDS level when it is over 500 ppm. As we said before, low TDS is desirable. A TDS on the low end of the scale will only mean that it may take longer for the copper-ion level to reach the correct level. Small pools may not need a high TDS level to get sufficient copper-ions into the water. The R-20 and R-40 units on low TDS levels may take longer to get to the desired levels than the RC-50 because of the electrode configuration.

Add 10 pounds of salt per 10,000 gallons and check the milliamp reading the next day. Add more salt if the TDS level is not up to 300 or the milliamp reading is not 100/per 10,000 gallons.

Please make sure the TDS meter is accurate. You rarely will need to add salt to a pool. If you have to, explain to the customer what you are doing and why. If he complains about his pool water turning into a saltwater pool, he is wrong. Saltwater contains about 3,000 pounds of salt per 10,000 gallons (or a TDS level of 36,000). So adding 10 pounds of salt won't make a difference. The TDS level will go up over 300 ppm anyway by adding normal pool chemicals (see chart J-3) or from body oils and suntan lotion coming off bathers.

## **DECREASING THE TDS**

If the TDS level increases above 1500 ppm, we recommend that you decrease it. It will be much easier to keep water clear if the TDS is lowered. Excessively high TDS is usually found in hot, dry, arid climates.

To lower TDS, partially drain and refill the pool. Despite the high cost of water in some areas, lowering the TDS is still very economical compared to chemical exposure of letting it rise. The TDS can be kept under control with a sand filter by letting it backwash longer.

The Clearwater system will work regardless of how high the TDS level becomes, but it is much easier to have clear water, use much less of an oxidizer, and do less damage to the pool walls if the TDS level is below 1500 ppm.

If draining the water is not an option, the TDS can raise to well over 2,000 without any serious consequences. Again, it takes several years on most cases to get this high.

## **FALSE READINGS**

Believe it or not, some TDS meters can be affected by the presence of strong radio waves. So, if you're testing the water and there is a ham operator nearby, have him hold up his broadcast while you're doing the TDS test!

# CHART J-3

Effect of Common Pool Chemicals on Total Dissolved Solids (TDS)							
Common Name	Chemical Name	Form	pH	Increase in TDS (per 15,000 gallons of pool water)	Neutralizer Required	Increase in TDS due to Neutralizer (per 15,000 gallons)	Total TDS Increase for Chemical & Neutralizer (per 15,000 gallons)
Gas Chlorine	Chlorine gas	Gas	0.1	8 ppm/pound	1 ½ lbs. Soda Ash per pound	12 ppm	20 ppm
Liquid Chlorine	Sodium Hypochlorite	Liquid	13.0	18 ppm/gallon	16 oz. Muriatic Acid per gallon	2 ppm	20 ppm
Cal-Hypo	Calcium Hypochlorite	Dry	11.9	8 ppm/pound	4 oz. muriatic Acid per pound	1 ppm	9 ppm
Lithium Hypo	Lithium Hypochlorite	Dry	10.8	8 ppm/pound	3 oz. Muriatic Acid per pound	1 ppm	9ppm
Trichlor	Trichlor-s-triazinetrione	Dry	2.5-3.0	8 ppm/pound	4 ½ oz. Soda Ash per pound	2 ppm	10 ppm
Dichlor	Sodium Dichloro-s-triazinetrione	Dry	7.0	8 ppm/pound	None	None	8 ppm
Bromine Tabs	1-bromo-3-chloro-5,5-dimethyl-hydantion	Dry	3.6	8 ppm/pound	3 ½ oz. Soda Ash per pound	2 ppm	10 ppm
Bromine Salts	Sodium Bromide	Dry	7.0	9 ppm/pound	None	None	8 ppm
Muriatic Acid	Hydrochloric Acid	Liquid	0.1	15 ppm/gallon	Non applicable	Non applicable	15 ppm
Dry Acid	Sodium Bisulfate	Dry	1.4	8 ppm/pound	N/A	N/A	8 ppm
Soda Ash	Sodium Carbonate	Dry	13.0	8 ppm/pound	N/A	N/A	8 ppm
Sodium Sesquil	Sodium Sesquicarbonate	Dry	10.1	8 ppm/pound	N/A	N/A	8 ppm
Sodium Bicarb	Sodium Bicarbonate	Dry	3.4	8 ppm/pound	N/A	N/A	8 ppm
Non-Chlorine Shock	Potassium Monopersulfate	Dry	8.3	8 ppm/pound	4 oz. Soda Ash per pound	2 ppm	10 ppm
Conditioner	Cyanuric Acid	Dry	3.0	8 ppm/pound	4 ½ oz. Soda Ash per pound	2 ppm	10 ppm

# K. CYANURIC ACID (stabilizer)

## DEFINITION

Cyanuric acid is a stabilizer used in chlorinated pools to reduce the chlorine degradation caused by ultraviolet light. Since chlorine in water is rapidly destroyed by direct sunlight, cyanuric acid is added to increase the overall time chlorine will remain in the pool to provide sanitation. Cyanuric acid is a urea-based chemical that passively bonds to free available chlorine, enabling the free chlorine to sanitize the water while being protected from the sun.

## HISTORY

Cyanuric acid was discovered in 1917 by two U.S. Department of agriculture employees who found it occurring naturally in soil in Florida, Indiana, Maine, Texas, and Washington D.C. they determined that cyanuric acid was produced by the breakdown of a chemical called urea, which occurs naturally in urine and other body fluids following the digestion of protein and can also be produced synthetically. They couldn't find anything harmful about cyanuric acid and they couldn't find any use for it back in 1917.

In 1959, two men named Robert J. Fuchs and Irwin A. Lichtman applied for a patent for the use of a chemical called cyanuric acid as a chlorine stabilizer in swimming pools. The men worked for a New York company called Food Machinery and Chemical Corp. or more recognized FMC. The patent was finally granted in 1961.

Five years earlier, a researcher named Edgar Hardy had developed a chlorine and cyanuric acid compound that we all know today as trichlor. It was developed as a handy way to disinfect army mess kits in the field! Hardy's employer, Monsanto Chemical Co. of St Louis, patented the product as a disinfectant. After it was proven that cyanuric acid could be a great benefit in swimming pools, Monsanto paid FMC a royalty until the patent expired in 1978.

Today, pools and spas form the largest market for cyanuric acid, although it also is used in bleaches, mechanical dish washing products, cleansers, animal feeds and fertilizers. Recently, cyanuric acid has been found useful in removing pollutants from diesel engine emissions. More than 100 million pounds of cyanuric acid and stabilized chlorine products are used yearly by the pool and spa industry. If only those two departments of agriculture employees knew this in 1917!

Cyanuric acid is produced by heating urea to a temperature at 450 degrees centigrade, which produces an impure form of cyanuric acid. This procedure of transforming a compound into another substance by heat alone is called pyrolysis, coming from the Greek word pyro which means "fire". The cyanuric acid is then purified in sulfuric acid.

Cyanuric acid is generally sold in a granulate form, although a powder form is available. The powdered form dissolves more easily in water, but is much more difficult to handle because a quick gust of wind could blow it all over the place. It is also difficult to package because it easily gums-up the packaging machinery.

## IMPORTANCE

Cyanuric acid is only important to pools that are outside in areas with a lot of direct sunlight – that use chlorine. In a pool with a **Clearwater ionizer**, cyanuric acid is not required because they are not using chlorine (residential pools). In commercial pools, it is important to use cyanuric acid to keep chlorine costs down.

## RECOMMENDED RANGE

In a residential pool with the **Clearwater ionizer** system, no cyanuric acid is required. With an outdoor commercially used pool (where some chlorine is required, the reading should be between 30 ppm – 50 ppm).

## TESTING OF CYANURIC ACID

Testing for cyanuric acid is most commonly done with a turbidometric test, which uses a test reagent to precipitate the cyanuric and then uses the relative cloudiness (turbidity) of the reacted sample to gauge the CYA concentration.

A reagent called melamine is used. The melamine combines with the cyanuric acid in the water to form a fine, insoluble, white precipitate that causes the water to cloud in proportion to the amount of cyanuric acid in it. When the water clouds, it becomes more difficult to see an object in it.

Some cyanuric acid test kits contain a specially designed vial, which has a black dot painted in the bottom of it that is clearly visible when it is filled with water but becomes more difficult to see when the CYA has been precipitated. How much of the dot you can see is compared to a chart included in the cyanuric acid test kit to indicate the concentration in ppm that is usually on the side of the sample bottle

## HIGH CYANURIC ACID

Very high cyanuric acid levels of over 200 ppm can affect the Clearwater system. The copper-ions can get tied up making them useless/ high cyanuric acid levels also make chlorine and oxidizers less effective if cyanuric acid levels are over 100 ppm.

Cyanuric acid levels over 100 ppm will require much more chlorine in a chlorinated pool, and more use of an oxidizer in a Clearwater pool (see chart K-1)

More importantly, many municipalities have set the maximum permissible level of cyanuric acid in a public pool or spa at 100 ppm. Anything over that can cause the health departments to close down the pool. However, in the past year or so, some chemical manufactures dispute that high levels of cyanuric acid are a health risk.

## **LOW CYANURIC ACID**

Low cyanuric acid levels have very little effect on chlorine when below 25 ppm, so a minimum of 25 ppm should be required if any cyanuric acid is needed in the pool.

## **FACTORS OF CYANURIC ACID**

Pools that are using stabilizing chlorine (dichlor or trichlor) have cyanuric acid in them and is usually available in a stick or tablet form. This will always increase the cyanuric acid over time unless a lot of water is being splashed out or back washed.

Otherwise, factors affecting cyanuric acid include the direct adding of cyanuric itself- available in granular or powder forms.

Cyanuric acid does not evaporate, so it stays in the water unless back washed or drained out.

## **HOW OFTEN TO TEST**

Cyanuric acid only needs to be tested in the pools that require cyanuric so that the level does not fall below 30 ppm. Below this level, it is useless. Testing should be done at least once a year, or more frequently if using stabilizer chlorine (dichlor or trichlor). The levels should be kept under 100 ppm.

## **INCREASING THE CYANURIC ACID LEVEL**

You can increase the cyanuric acid level by using the stabilized chlorine, or by adding cyanuric acid itself.

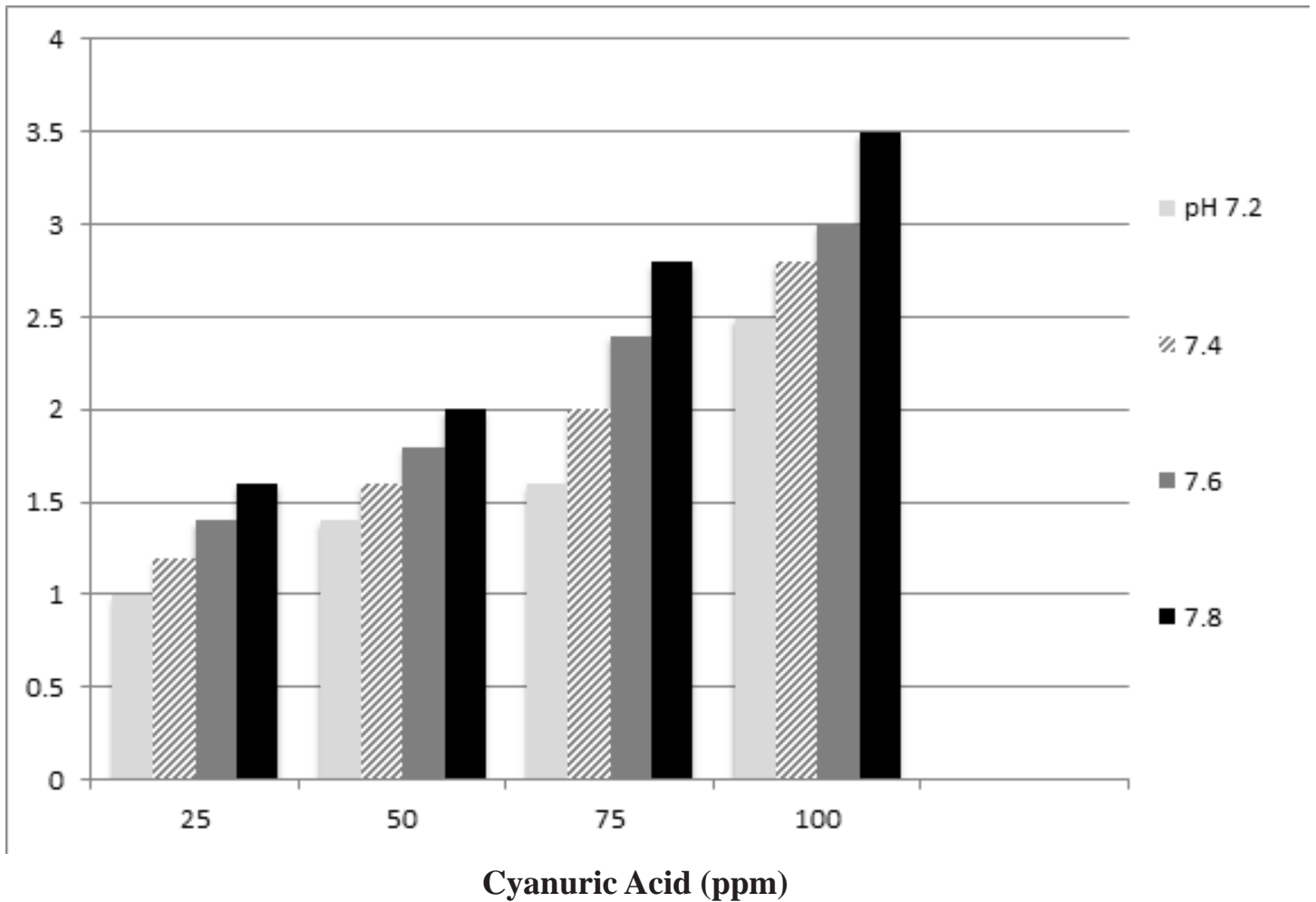
## **DECREASING THE CYANURIC ACID LEVEL**

The only way to decrease the cyanuric acid level is to partially drain and refill the pool or discontinue the use of stabilized chlorine.

# Chart K-1

## Effects of Cyanuric Acid & pH On Free Chlorine Requirement

Chlorine Required (ppm).



For example: it takes a chlorine level of 3.5 ppm at a pH of 7.8 and a cyanuric acid level of 100 ppm to be as effective as 1.0 ppm CI at a pH of 7.2 and a cyanuric acid level of 25 ppm.

# L. COPPER-IONS

## (and the MineralPURE Ionizer)

### DEFINITION

Copper is a natural mineral that is the primary source of disinfection of the **Clearwater Ionizer**. Copper's job is to kill algae in pool and spa water.

### IMPORTANCE

Copper-ions are an effective algacide. It is sold by pool store owners to kill black algae, the toughest of all. It is used in lakes, reservoirs, and even for treating drinking water by state health departments.

Oxides and sulfates of copper are used for pesticides, algacides and fungicides. Copper is frequently incorporated into paints and wood preservatives to inhibit growth of algae and invertebrate organisms.

Copper occurs as a natural or native metal and in various mineral forms such as cuprite and malachite. Copper has been mined and used by man in a variety of products since prehistoric times. Other uses include electrical products, coins, wire, piping, and metal plating. Copper is frequently alloyed with other metals to form various brasses and bronzes.

Copper is an essential trace element for the propagation of plants and performs vital functions in several enzymes and a major role in the syntheses of chlorophyll. A shortage of copper in soil may lead to chlorosis, which is categorized by yellowing of plant leaves. In copper-deficient soils it may be added as a trace nutrient supplement to other fertilizers.

Copper is required in animal metabolism. It is important in invertebrate blood chemistry and for the synthesis of hemoglobin. In some invertebrate organisms a protein, hemocyanin, contains copper and serves as the oxygen-carrying mechanism in the blood.

Young children require approximately 0.1 mg/day of copper for normal growth and the daily requirement for adults was estimated to be about 2 mg/day

With the **Clearwater** ionization system, copper is used to attack and help kill algae that can grow in the pool or spa.



## RECOMMENDED RANGE

The recommended range of copper-ions should be between 0.20 and 0.30 ppm. Any amount lower than 0.20 will require a chlorine residual in the water to effectively kill algae. A reading over 0.30 ppm and an improperly balanced pool can cause staining.

In some hot, rainy, humid climates, such as Florida, Mexico, Indonesia, a copper reading of **.40 ppm** may be required. Make sure all pool readings are in the correct range, and if the pool is a marcite/gunite pool, a sequestering agent should be used (see **Sequestering Agents** section).

## TESTING OF THE COPPER-ION LEVEL

All **Clearwater** systems include a copper-ion test kit. Be sure to follow the directions included with the test kit. Because you are testing such small increments (1/20<sup>th</sup> of one part per million) of copper-ions, it is difficult to find a test kit that is user friendly, accurate and affordable. Do not rely on readings done by a pool store. They use very basic, high increment copper kits that do not give the definitive reading that is required.

The best test kit to meet those standards is one by LaMotte Chemical - and it is included with every unit sold. We have been using LaMotte test kits since 1988 and are very satisfied with their pricing. It is also user friendly and produces very accurate readings. **Clearwater** stocks several hundred complete test kits and replacement reagents at all times, with very affordable pricing.

The test is fairly simple, but if not done properly inaccurate test results will occur.

- 1) Fill the test tube to the 10 ml level near the top with water sample.
- 2) Add 5 drops of copper bottle "A". Cap and invert to mix
- 3) Add 5 drops of copper bottle "B". Cap and invert to mix.
- 4) Insert tube into holder. Wait **3 minutes** for color development.
- 5) Remove cap and place tube bottom **½"** above color chart.
- 6) Match color by looking down the tube from the top. Compare to the nearest shade of blue among the 8 possible from 0.05 – 1.0.

### Important notes:

- A.) Make sure you wait the full 3 minutes. It takes that long for the test to fully develop.
- B.) Make sure to hold the tube ½" above the chart and compare.
- C.) When holding the test tube to compare results, make sure you look down from the top of the test tube, not from the side. This happens once in a while, where the customer will complain that there aren't any copper-ions in the water, or a very low amount – but when done properly, the reading is much higher – and accurate.
- D.) Make sure test kit is kept out of the heat and direct sunlight, as this will give false readings.
- E.) Replace reagents every year, or replace the entire kit.

## HIGH COPPER-ION READING

The only problem associated with a high copper-ion reading is the risk of staining on concrete pools if the pH, total alkalinity, calcium hardness or TDS is high for a long period of time.

Overkill, by using an excessive concentration of copper, should never be practiced. More is not better in this case. If the water is cloudy, or there is algae in the pool, and the readings are in range, do not turn up the control knob thinking more copper-ions will solve the problem – because it won't. This only increases the possibility of staining and wears out the electrodes.

There is no health risk associated with a high copper-ion level. Even at .30 ppm the copper level is still less than ¼ of the EPA's standard for drinking water! Since copper is not absorbed through the skin like chlorine, a person would have to drink two gallons of pool water just to acquire the amount of copper in a single vitamin pill! The human body actually needs copper; it doesn't need chlorine.

## LOW COPPER-ION READING

The worst thing that a low copper-ion level can do is allow algae to grow. If this happens, shock the pool with a little bit of chlorine to burn out the algae, brush the pool, and correct the copper level. Never add granulated chlorine directly to the pool – it can cause immediate black stains. Use liquid bleach of chlorine, or dissolve granular chlorine in water and pour it into the skimmer.

## FACTORS OF COPPER-ION LEVEL

The main flow of copper-ions in the water, of course, is directly from the control box and the electrodes. This will regulate the exact amount of ions you want to release into the water (assuming all other factors are in range).

But there are other sources of copper. One is from copper piping. Some older pools used copper piping before the use of PVC, and some pools have copper piping near the heaters. When the pH gets below 7.0, copper can etch from the piping, putting copper sulfate into the water. This is different than the copper-ions being produced by the ionizer. A lot of the copper piping is actually a mixture of other minerals besides copper.

Another factor of copper can be from copper-based algaecides that are sold in any pool store. Again, this is not the same as the copper-ions the **Clearwater** ionization system produces, but it will show up on the copper test kit.

For more details on factors affecting the copper-ion level, see the chart later in this section.

## HOW OFTEN TO TEST

The copper-ion level should be tested once a week on residential pools, once a day on commercial pools. This is to make sure the proper amount is always in the water.

If the pH and total alkalinity readings are kept in range, the copper-ion level will generally stay in the same range all season long. The warmer the water, the greater chance algae will attempt to grow - thus more demand for copper-ions. Generally, the ionizer setting will be double during the hot summer months, as opposed to during cooler months.

Remember - the digital readout is not an indication of the copper-ion readout, and a separate test will be required. This readout will be much higher in the summer months.

## HOW THE IONIZER WORKS

The **Clearwater ionizer** works by passing a low-voltage, alternating DC current through a set of metallic electrodes, placed in-line of the circulation system and set slightly apart from one another. The voltage causes some of the outermost atoms of the electrodes to lose an electron, thus becoming positive ions, which attempt to flow across the space between the electrodes but instead are carried away by the flow of the water.

The electrodes are located in an “ion chamber” plumbed in-line after the pump and either before or after the filter. A separate control box supplies a variable, low voltage DC charge (12 volts and up to 1 amp in power) to the electrodes. The current alternates every 5 minutes on the **RC & CS** series units, and every 90 seconds or so on the **R-20/R-40** units. This is to allow an even wear and tear on the electrodes. The display window on the **RC & CS** series units is a reading of how many milliamps that are actually being passed through the electrodes. The **R-20/R-40** units do not have a digital readout, but this can be determined by using a volt meter and follow directions in the installation manual or see “If the copper level won’t increase” section in this book. The **RC & CS** series are digital units with microprocessor designed circuit boards with non-volatile memory for continuous monitoring and adjustment. The control knob works in continuously variable increments of 25mA, from “**OFF**” to **600** on the **RC-50** units, and **1000** on the **CS** units.

The **R-20/R-40** units are not digital, and have settings from “**OFF**” to 1-5. Five is the full maximum the unit can put out. An LED will brighten as the control knob is turned up.

There are 4 main factors that can affect the milliamp reading:

- 1.) An air pocket in the electrode chamber will give a lower reading or none at all.
- 2.) The wear and tear of the electrodes (thinning of the bars and the distance they are apart) will offset the TDS readings and give a low reading.
- 3.) Build-up of scale and/or blue-greenish buildup of worn copper ions on the electrodes.
- 4.) The TDS is a major factor of milliamp readings when under 600 ppm.

# GETTING THE DESIRED COPPER-ION LEVEL

When turning on the **Clearwater Ionizer** for the first time, make sure the copper level has been first. Make sure the water is clear, and not full of algae. Make sure no metal out removers or sequestering agents that can remove copper have been added to the water for the past year. Also check to see if any algaecides have been added to the water recently. When trying to reach the desired copper-ion level, there are several factors that affect how long it will take.

## FACTORS AFFECTING THE COPPER-ION LEVEL

- 1.) **pH level.** A pH level over 7.8 will allow copper-ions to fall out of solution. The most effective pH level is between 7.2- 7.4. If the pH level was over 7.8 and lowered to 7.2, it may take a day or two to get the levels back up to normal. ***Very Important! Keep pH between 7.2 - 7.6***
- 2.) **Total Alkalinity.** Directly affects the pH. Desired levels are 80-100. The actual total alkalinity reading itself does not affect the copper-ion level
- 3.) **TDS levels.** These readings need to be at least 600 to have a full readout on the RC-50 units, and about 500 on the R-20/R-40 units. Units are oversized for most areas (depending on water temperature) and may never need to be turned up to “full blast”. A low TDS level is cause for a low readout on the digital display.
- 4.) **Water temperature.** Like pH and TDS levels, the water temperature is a major factor of the copper-ion level and how high the setting needs to be. The warmer the water, the more likely algae can grow - thus a higher demand for copper-ions. Water that approaches 90 degrees will need the unit set at double the amount of milliamps than water at 75 degrees to obtain the proper copper-ion level.
- 5.) **Electrical hookup.** All units are factory set at 220VAC. The unit must be set at the correct voltage as per hookup. If a unit is set at 110VAC and the voltage is 220VAC, the internal fuses will blow. If an R-20/R-40 unit is set at 220VAC and the voltage is 110VAC, the unit will work at 1/2 efficiency.
- 6.) **Wiring hookup.** Make sure all wires are connected to the electrodes and to the power source.
- 7.) **Plumbing hookup.** The electrode and flow-cell chamber must be installed on the return line after the pump and either before or after the filter. If the unit is an R-20/R40, make sure the flow-cell tee is installed downward or in a vertical position so that no air pocket can form in the chamber.
- 8.) **High amounts of algae in water.** If the water is cloudy and full of algae, this will “consume” up all of the available “free-copper” ions in the water, leaving you with low readings. Always shock the pool with chlorine if algae and cloudy water exist.
- 9.) **Check the Copper-Ion Test Kit.** An old, outdated test kit can give false readings. Always keep the test kit in room temperature away from direct sunlight and heat.

- 10.) **Electrode Condition.** Old, worn and coated up (calcium, greenish oxidized copper) electrodes will inhibit a current to be passed between the electrodes, causing no copper to be produced and a low readout on the digital display. See “Cleaning and Changing the Electrodes” section in this book.
- 11.) **High Phosphates in water.** Recent advances in water technology have found that high a level of phosphates in the water is the main breeding ground for algae. By removing phosphates in the water, you greatly reduce algae growth - and copper-ion usage.
- 12.) **High Nitrate, Nitrites, Ammonia, Sulfate Levels.** Nitrate levels over 50 ppm and sulfate levels of over 70 ppm can cause problems with the copper-ion levels. This is rarely a problem and only needs to be tested if all other factors have been checked and there is still a problem. The only way to get rid of these is by partial draining of the pool.
- 13.) **Sequestering/Chelating agents.** The addition of a chelating agent in the past year will form a bond with metal ions, allowing them to be filtered out. This includes the copper and silver ions, and is one of the major reasons why someone cannot get the copper-ion level up to proper levels. Sequestering agents will hold metals in solution so they don't precipitate and form stains. See “Sequestering/Chelating Agents” section of this book.
- 14.) **Filtration and Circulation System.** If the filter is clogged up and no circulation is taking place, the ion level being produced at the flow-cell chamber is greatly reduced by 50% and more. The amount of water passing through the electrode chamber is extremely important.

FOR A MORE DETAILED EXPLANATION OF REASONS AFFECTING THE COPPER-ION LEVEL, SEE SECTION “*IF THE COPPER-ION LEVEL WON'T INCREASE...*” IN THIS BOOK.

## HOW LONG WILL IT TAKE TO OBTAIN THE PROPER COPPER-ION LEVEL?

When installing the unit for the first time, make sure none of the above 14 factors can affect the ionizer. How long will the ionizer take to reach the proper ion level? What level should you set the ionizer at? Several factors (such as the 14 listed above), the number of hours the pump is on, pump size, and the setting of the unit is all factors. The units themselves also release ions at a different rate.

The answer to the above questions is a tricky one. However, assuming the pH, total alkalinity and other factors are in place, the water is clear and free of algae, it will take about 12 - 20 hours with the RC-50 unit (set at the full 600 mA of power) per 10,000 gallons to get up to .20 - .30 copper-ion level. The R-20/R-40 units (set on 5) will take at least 24-36 hours to obtain these levels. This is with the filter cleaned, good circulation taking place, new electrodes, no chelating agents, phosphates... etc. in the water.

When you install the **Clearwater Ionizer** for the first time at a house, it is important to coordinate with your customer a follow-up date and time. You never want to over ionize the pool, so it is important that the water is closely monitored the first week or so. What should you set the ionizer at? 100, 200, 600? How many hours should the timer run for - 6 hours, 8, hours, 24 hours? This all depends on when the water can be tested by a qualified person, and adjust the ionizer accordingly. By using the above figures, you need to calculate where to set the unit and the number of hours to run it.

**Example:** you will follow up the next day (24 hours later) and the customer has an RC-50 unit installed. Assuming all the above factors are in line, it will take 12-20 hours to fully ionize the pool. If the pool is 20,000 gallons, the unit should be set on max. (600) assuming it takes 12 hours to ionize 10,000 gallons (always start on the low end of 12 hours, not the high end of 20 because you never want to over ionize the pool.

Example: you cannot get back to the house for a week. The unit installed is an RC-50, and the pool has 30,000 gallons. The timer is set to run 8 hours per day. Assuming it takes 12 hours to ionize 10,000 gallons at 600 mA, it would take 36 hours, or 4 1/2 days at 8 hours per day with the pump running. That is too quick of a period because you would not be back for 7 days. Thus you would need to cut the ionizer back from full blast (600 mA) to about 350-375 mA.

## **ONCE THE DESIRED LEVEL IS OBTAINED, HOW LONG SHOULD THE UNIT BE TURNED ON FOR AND AT WHAT SETTING?**

The timer should always be set at the same setting as the customer had it set for before the ionizer was sold, unless it was on for too long or too short. Residential houses should run about 8 hours a day, or when the pool is turned over 1 ½ times a day. This can be calculated based on pump size and the number of gallons. Commercial pools should run 24 hours a day, 7 days a week.

So when the ionizer is to be set, always base it on the above hours the pump is running. A house without a timer may present problems, and may run several days at 24 hours and not run at all if people forget to turn the pump on and off. Always recommend they get a timer.

Once the ionizer has obtained the proper reading, where should the ionizer be set at? As a rule of thumb, the unit can be set at 100 per 10,000 gallons of water, per 8 hours a day of running (RC-50 units). Wait a day or two and test again. The water temperature makes all the difference - warm water may require a setting of 125-150 per 10,000 gallons, while cool water may only need a 50-75 setting per 10,000 gallons.

The best way is to simply turn the control knob down a notch (R-20/R-40 units) if the copper is too high, or turn it up a notch if the copper reading is too low. On the digital units (RC-50/CS units), you can lower the digital reading by 25 or 50 if the reading is too high, or vice versa, raise the digital reading by 25 or 50 if the reading is too low.

By adjusting the ionizer every day or so for the first week or two, you will find that once the proper setting is found, it will stay on that setting automatically for the entire season.

This may all seem complicated, but once you have done an installation a couple of times, you will find it rather easy to regulate.

**You can find more details in the “Installation and Pool Care Manual” included with every ionizer.**

If you ever have any problems, always call **Clearwater Enviro Technologies, Inc.**, direct and we will gladly help you with any questions.

# M. SILVER-IONS

## DEFINITION

Silver is a natural mineral that is a primary source of disinfection in the **Clearwater Ionizer**. Silver's job is to help kill bacteria and viruses in pool and spa water.

## IMPORTANCE

Silver has had a long history as a bacterial killer. During the plague-ridden middle Ages, mothers knew that to place a silver spoon in an infant's mouth was a way of warding off disease. Prophylactic silver reduced blinding infection in newborn infants by 98% when first introduced in the late 19th century and remains legally required in the United States, Canada, Denmark, Norway and Iceland to name a few. The addition of silver to sulfadiazine renders it 200 times more effective and is now the standard antibacterial treatment for burns and any other type of open wounds.

In remote towns in Mexico, silver and salts are mixed in a protein carrier which is painted on the sides of large water storage tanks. This effectively kills bacteria; virus, algae and slimes for about a year under conditions where chlorine would quickly evaporate -leaving the water unprotected.

Today, silver is used as the drinking water purification for half of the world's airlines, used in over 1,000 passenger ships and in many offshore drilling rigs. Soft drinks, beer, liquor, wine and other beverages are rendered pure and more palatable by the addition of silver in over 70 countries throughout the world.

We know that silver kills some 650 bacteria, while the average antibiotic kills approximately half a dozen. Silver is the only effective way to kill certain viral strains such as Legionella Pneumophila, the virus responsible for "Legionnaire's Disease".

Throughout this extensive use of silver to halt the growth of bacteria in drinking water, and a century of use of silver to protect the eyes of newborns, and the decades of the use of silver on burns and other open wounds, there has never been a report of an allergic or toxic reaction to silver.

It was NASA that harnessed what nature already knew and designed an ionization system for their Apollo flights. The Johnson Space Center developed an electrolytic silver ion generator only slightly larger than a cigarette pack and weighing only 9 ounces. This small ionizer required only minimal power and no astronaut monitoring. Mounted at various locations in the potable water supply and wastewater systems, the ionizer would dispense silver-ion concentrations of 100 - 300 parts per billion.

In 1962, silver was approved for use in drinking water by the United State Public Health Service.



## RECOMMENDED RANGE

The recommended range of silver-ions in the water is 1 - 5 ppb (parts per billion).

## TESTING OF SILVER

Testing of silver-ions is not required because if the copper-ion level is in range, the silver-ion will be also. The concentration of silver is pre-mixed in the **Clearwater Electrode**. Maintaining the proper copper level will ensure the proper silver level as well.

The U.S. Environmental Protection Agency allows 100 parts per billion (ppb) of silver in drinking water, but silver levels below 1 ppb have been shown to sterilize water. Silver is not absorbed by the skin like chlorine is. There is more silver in the average meal than in a gallon of ionized water.

# N. SEQUESTERING / CHELATING AGENTS

## DEFINITION

Sequestering and chelating agents act as a metal controller and stain/scale remover. These products neutralize the effect of metals in water, appearing to lift metal stains and remove metal discoloration from water. Chelating agents resolve the problem when it appears, while sequestering agents provide preventive measures.

## IMPORTANCE

The importance of a sequestering agent is that it can prevent staining in a pool, but if not used properly, it can tie up the copper-ions in the water, causing "tied-up" copper, which like "tied up chlorine" can be totally ineffective.

## RECOMMENDED RANGE

The recommended range of a sequestering agent in a pool is hard to pinpoint. Readings of over 5ppm of products that can tie up the copper and silver-ions from doing their job, however, using products (like United Chemical's Pool Stain Treat or Jack's Magic product line) that do not tie up ions require a reading of 10-12 ppm to prevent staining.

## TESTING OF SEQUESTERING AGENTS

The testing of sequestering agents in the water is done by testing the *Organo-Phosphorate* level in the water. The actual reason for the organo-phosphorate testing was to measure the amount of compounds used as an inhibitor in cooling systems.

These organo-phosphorate test kits use a special combined buffer-indicator tablet in conjunction with a standard thorium nitrate solution. The tablet contains a screened vylenol orange indicator together with a buffer mixture which provides the correct conditions for the test. This tablet eliminates the tedious pH correction procedure and ensures an improved green to purple end point color change.

When testing for sequestering agents, we recommend you use the Jack's Magic Sequest Test Kit (available from **Clearwater**).

## FACTORS OF SEQUESTERING AGENTS

The Sequest test can be the sum of metal outs, stain removers and chelating agents in the water. Other substances that can show up in the test are aluminum and polyphosphates.

# WHY TEST FOR SEQUESTERING! CHELATING AGENTS?

There are two main reasons why you should test for sequestering/chelating agents –

A.) If the pool installed is a marcite/gunite pool, the use of a sequestering agent should be used and measured for the proper amounts in the water at any one time to prevent staining (see section “Pool Stain Prevention”).

B.) If any metal out, stain, or scale inhibitors have been added to the water in the past year, some of these can tie-up the copper ions from doing their job. They can actually remove the ions from the water, causing headaches for the pool owner.

Before any install of the **Clearwater Ionizer**, you should ask the pool owner if any algaecides or metal out removers have been added to the water in the past year. However, lots of people either forget or are mistaken what was put in the water and won't tell you. These products can stay in the water for long periods of time, some for as long as a year – if added in high doses.

The best safeguard is to test the sequestering agent level anyway - and refer to it if problems exist. If the test shows over 4 ppm, ask the customer what he has added to the pool for the past 12 months. If he has added any metal out removers, they will actually remove the copper-ions from the water, thus making a proper copper-ion level nearly impossible.

Some products that **will cause problems** include Sequasol, Cop-Out, Metal Magnet, *Aluminum Sulfate or Alum*. There are several others, but it difficult to keep track of the trade name and all of the “private labeling” going on.

The best thing to do is make sure the customer NEVER puts any products in the pool unless they are those mentioned in the Owner's Manual.

Some of the sequestering agents that do not affect the **Clearwater Ionizer** include *Pool Stain Treat* by United Chemical, and Jack's Magic Product line. Other products that do not cause problems are *Epi-Clear C-62*, *Super Blue* by Robards and *Sea-Klear* by Vanson. These products do an excellent job at clearing cloudy water by coagulating tiny particles and oily liquids that build up in the water so that the filter can remove them. These polymers will also help on filter efficiency. However, over-usage of these products can be counterproductive and actually tie up the copper-ions from working.

## **SOLVING PROBLEMS WITH SEQUEST! CHELATING AGENTS**

The only time you need to solve a problem with high sequestering chelating agents is if the product is removing the copper-ions from the water. The best thing to do is try to determine which products are in the water that are removing the copper-ions from the water. Remember - these products that remove metals can stay in the water for up to a year. If you locate the bottle, you may want to contact the manufacturer and ask them if this removes copper from the water. Be sure to test the Sequestering Agent level with the *Jack's Magic Sequest Test*. **THIS WILL TEST BOTH SEQUESTERING AND CHELATING AGENTS THAT WILL OR WILL NOT TIE UP THE COPPER-IONS.** There is no way to test for individual metal and stain removers.

If this reading is over 4 ppm, it may be an indication of the ions being tied up or removed from the water. The higher the reading, the more likely that this is the problem. But do not forget, if products like *Pool Stain Treat* or *Jack's Magic* have been added to the water, this will show up on the Sequest Test Kit also.

If the pool is having trouble maintaining the copper-ion level, and chelating/sequestering agents have been confirmed to have been added to the pool in the past year, and show up on the test kit, the water will need to be partially drained - or super shocked with 10-20 ppm of liquid chlorine. This will “burn” the agents out of the water. After shocking the pool, wait a couple of days, and then test the sequestering agent level. It should have dramatically gone down. After the chlorine level goes down, the copper-ion level should start to go up.

If problems still persist, repeat the chlorine shocking again.

## **SEQUEST TEST FOR STAIN PREVENTION**

If the pool that is being installed with an ionizer is a marcite/gunite pool, a sequestering agent like *Pool Stain Treat* or *Jack's Magic* should be added on a regular basis (for more details, see *Pool Stain Prevention* section”). By using the *Jack's Magic Sequest Test Kit*, you can determine if there is enough stain removers in the water at any time.

Follow directions included with the test kit. An ideal level should be 10-12 ppm at any given time. Any reading lower than this may not be enough and staining can occur. Some pool experts claim that chlorine effects the sequestering agents from doing the job, so with the ionizer in place, try to oxidize with a non-chlorine type product to prevent staining.

# O. CHLORINE

## DEFINITION

Webster's dictionary describes chlorine as a "greenish-yellow, poisonous gaseous chemical element with a disagreeable odor used in the preparation of bleaching agents in water purification."

Chlorine used in swimming pools is used to kill algae and bacteria, and to oxidize the dead organic matter.

## IMPORTANCE

Chlorine's importance, as far as you are concerned, is to know everything about it because you are selling against it. You need to know how it works, the different types of chlorine available, how much it costs (to determine a pay-back period for potential buyers of the **Clearwater Ionizer**), its positives and its negatives.

Chlorine has been the primary use of swimming pool disinfection since the beginning of the century, and is still used in over 90% of pools today. However, due to increased awareness of the dangers of chlorine, the general public has begun to take a closer look at chlorine.

In this chapter, however, we will give you one of the most detailed looks at chlorine – its historical background, how chlorine actually works, the different types of chlorine, and how to test for it.

## HISTORY

The name "chlorine" comes from the Greek word *chloros*, which means "pale green". It is a pale greenish-yellow gas that is 2 1/2 times heavier than air. It will concentrate near the ground if released.

Chlorine was discovered in Sweden in 1774 by a scientist named K. W. Scheele, but it wasn't until 1820 that chlorine was confirmed as an element by an English chemist by the name of Sir Humphrey Davy.

Today, chlorine is the seventh largest chemical produced in the United States. Sales of chlorine were estimated at \$714 billion in 1990. Most people actually associate chlorine with swimming pools and drinking water, but the fact is, plastics, pulp and paper manufacturing account for 66% use of all chlorine produced. Drinking water uses only 10%.

# HOW CHLORINE WORKS

What happens to chlorine when it is added to the water? How is chlorine manufactured? Most gas chlorine is produced by the electrolysis of sodium chloride (salt) brine. This is done by passing electricity through the solution and separating it into its elements.

All chlorine - regardless of whether it is liquid, gas or dry - when added to the water does exactly the same thing - it forms hypochlorous acid (HOCL) & hypochlorite ions (OCI-).

Hypochlorous acid is the killing form of chlorine. It is the chemical that kills bacteria, algae and all pathogenic (disease-causing) organisms.

Hypochlorite ions are a relatively inactive form of chlorine. They have little or no killing power.

The pH of the water determines how much hypochlorous acid and hypochlorite ions are produced. The higher the pH, the less effective the chlorine is. The lower the pH, the more effective it is.

For chlorine to have its most effective killing power it would have to keep the pH at around 4.0. Unfortunately, you would dissolve the equipment and the plaster, and cause eye irritations to swimmers. On the other hand, if you kept the pH too high, your chlorine would be ineffective and you would plug up the plumbing and get scale all over the walls of the pool.

## pH Effects on Chlorine

<b>pH</b>	<b>% HOCl (Active form)</b>	<b>%OCI- (Inactive form)</b>
4.0	100%	0%
6.0	96.5%	3.5%
7.0	75%	25%
7.2	66%.	34%
7.5	48%	52%
7.8	31%	69%
8.0	22%	78%
8.5	8%	92%
11.0	0.03%	99.97%

\*Both Hypochlorous Acid and the hypochlorite ion are measured as free available chlorine on pool test kits.

# CHLORAMINES

As soon as you add chlorine to the water, it begins to combine with bacteria, algae and organic matter (anything that once lived). It will combine with ammonia and nitrogen compounds and organic matter containing ammonia, to form chloramines. These compounds come from our bodies in the form of saliva, sweat, urine and fecal matter. This will show up on the test kit as combined chlorine. Combined chlorine has little oxidizing power and is 98% ineffective, no matter what the pH is.

When a pool has a strong chlorine smell, and swimmers complain about eye irritation, the problem is not too much free chlorine, but not enough! There is too much combined chlorine in the water. The only way to get rid of the combined chlorine is to super chlorinate or shock the pool. In order to do this, you need to raise the free chlorine level to at least 10 times the combined chlorine level in the pool. This is called break point chlorination.

For example, if the combined chlorine level measures 2 ppm., you would have to raise the free chlorine level to 20 ppm to remove the combined chlorine. It is always better to add a little extra chlorine to be sure. If too little is added, none of the combined chlorine is removed.

One of the best ways for commercial pools to routinely eliminate combined chlorine is to use potassium monopersulfate or oxidizer. It eliminates the combined chlorine without raising the chlorine level, so people can swim immediately. This is the same oxidizer we recommend using the **Clearwater Ionizer** in residential pools. It also has an advantage that, if only half enough was used, half the combined chlorine is eliminated. Break point oxidation is not required.

When using potassium monopersulfate, use the same amount as you would granular chlorine.

## PROBLEMS ASSOCIATED WITH CHLORINE

The three best selling points against chlorine (aside from the point nobody likes swimming in it), is that nobody knows how much chlorine to put in the water and how often.

Because chlorine absorbs through the skin, it can dissipate very rapidly after a pool party. The average dog that jumps in the pool has the same effect as 40 people getting in! Chlorine also evaporates due to sunlight, humidity and rain. With chlorine, you are fighting in a never ending battle - you have to add more chlorine all the time to get rid of the dead chlorine. Chlorine only controls algae and bacteria, and fails to kill viruses.

The second main problem with chlorine is that chloramines have been proven to be toxic and cause cancer (see Marketing Manual for complete studies).

The third main problem is that chlorine is not the perfect algaecide. There are over 20,000 species of algae. However, only about 40 of these grow in swimming pools, some species are very easy to kill with chlorine. Others are very resistant to chlorine. If chlorine could effectively kill all species of algae, algaecides would not be on the market. Copper-ions are effective against all species of pool algae and are one of the most effective algaecides available.

# TYPES OF CHLORINE

There are six different types of chlorine on the market today. We will look at each one individually:

## 1. Gas Chlorine.

Gas chlorine is the purest form of chlorine you can buy. There are no fillers or carriers, so all the chlorine you add to the water is used for disinfecting, sanitizing and oxidizing.

Gas chlorine is the least expensive type of chlorine to buy. But it is also the most dangerous to use and store and is subject to the largest amount of government regulation.

Gas chlorine is distributed in one ton cylinders and then must be transferred to smaller (20 pound or 150 pound) tanks for normal use. Because of this the operator must be registered by the federal Environmental Protection Agency (EPA) as an applicator and repackager of chlorine.

The federal Department of Transportation (DOT) has specific regulations for transporting gas chlorine. In addition, many state and local agencies may require permits on the service vehicle.

The pH of gas chlorine is extremely low (about 1.5).

Because gas chlorine causes a very acidic condition in the water, it is necessary to add about 1 1/2 pounds of soda ash or about 2 pounds of sodium sesquicarbonate for each pound of gas chlorine used.

## 2. Liquid Chlorine.

Liquid chlorine or sodium hypochlorite (NaOCl) is manufactured by bubbling chlorine gas through a solution of caustic soda. The resulting liquid contains 15% available chlorine, but this concentration is very unstable, and within two weeks, the available chlorine concentration will drop to approximately 12.5%. Within 30 days, especially during the summer, it will drop to 10%. The process slows down or stops at around 9%. At 10% concentration, one gallon of liquid chlorine contains about one pound of available chlorine.

Because it does not have to dissolve, liquid chlorine makes hypochlorous acid (the killing form of chlorine) instantly when added to water. It can be used on regular or super chlorination. Liquid chlorine is nonflammable and is compatible with other water treating chemicals commonly found in swimming pools. Liquid chlorine also works fine with the ionizer.

Use and storage of liquid chlorine can have a great effect on its available chlorine content. Liquid chlorine should be stored in a cool place, shaded from sunlight. The available chlorine content of a jug of liquid chlorine will go from more than 12% to 9% in one day if it is sunny and the temperature gets up to 105 degrees F. If the temperature gets to 120 degrees (which it sometimes does in the back of a service truck) the available chlorine content can go from 12% to 9% in two hours!



The way you pour liquid chlorine into the pool can affect its available chlorine content. It should be poured into the pool with the jug as close to the surface of the water as possible. Aeration and sunlight can destroy part of the available chlorine content on the short distance between the mouth of the bottle or container, and the surface of the water. In fact, 1 % to 2% of the available chlorine can be lost by pouring the chlorine from only four feet above the water's surface on a hot, sunny day.

The pool pump must be on when adding the liquid chlorine to the water, and the serviceman should walk around the pool as he adds the chlorine. If the pool has cyanuric acid in it, and you stand in one spot while the chlorine is being poured into the pool, the sunlight can begin to destroy the chlorine before it has a chance to mix with the cyanuric acid and be protected by it. You can lose 1 % - 2% by not walking it around.

It is also best to add the liquid chlorine after sunset, to keep as much from evaporating as possible.

The pH of liquid chlorine is 13, so it causes a very alkaline condition to occur in the pool - that is, it drastically raises the pH. It is therefore necessary to add about one quart of muriatic acid per 2 gallons of liquid chlorine.

Liquid chlorine will increase the total dissolved solids (TDS) level about 10 ppm for each gallon of liquid chlorine added.

Household bleach, typically used to bleach white clothes, is the same as liquid chlorine - only 1/2 as strong. The other half is simply water. The 5% - 6% active chlorine will do the same as liquid chlorine, but will take twice as much. If your customer doesn't believe the bleach is the same stuff as liquid chlorine, have him look at the contents of any bleach container - usually 5.25% sodium hypochlorite.

### **3. Dichlor.**

Sodium dichlor (sodium dichlor-s-trizinetriene) or chemical formula  $(C(O)NCl)_2(C(O)NH)$  is the only popular type of chlorine that does not require the addition of either a neutralizing chemical or cyanuric acid.

Sodium dichlor is produced by adding soda ash and cyanuric acid to a solution of trichlor. When dried, the result is a granule that may contain 56% or 62% available chlorine, depending on the method of manufacture. The 56% formulation is by far the most readily available.

Sodium dichlor is fast dissolving, will not cloud the water and has a long shelf life. It can be used for regular and super-chlorination. Because it is fast dissolving, it cannot be used in a dry chemical feeder. Nor can you pre-dissolve it and dispense it in a liquid chlorinator.

One pound of sodium dichlor contains slightly more than .56 of a pound of available chlorine.

Of the six most popular types of chlorine, dichlor is the most expensive per pound of available chlorine. It does not, however, have any “hidden cost” associated with it.

Because use of sodium dichlor can cause a building of cyanuric acid in the pool water, it is necessary to check the cyanuric acid level more frequently.

Dichlor has a near neutral pH of 6.8 - 7.0 and does not require any neutralizing chemical to be added to the pool water. And because it contains cyanuric acid, it does not require the addition of that chemical.

#### **4. Trichlor.**

Trichlor or trichlor-s-triazinetriene (try that word in a spelling bee and you can see why we simply call it “trichlor”!), contains the highest percentage of all types of chlorine compounds. Its chemical formula is  $C_3Cl_3N_3O_3$ .

Trichlor is produced by drying and cooling the sodium salt of cyanuric acid in the presence of chlorine gas. The resulting compound contains 90% available chlorine.

Trichlor is mostly available in one inch and 3 inch tablets, or in a stick form. It has a very long shelf life, and is very slow dissolving, so it works extremely well in floaters and erosion type feeders. It can be used for regular chlorination, but not for super chlorination because it dissolves too slowly.

The granular form can be used as a “spot algacide”. Trichlor does not require the addition of cyanuric acid to the pool water.

Because trichlor is highly acidic, it can harm equipment or pool plaster if improperly used. The pH of trichlor is about 2.8 - 3.0. It is necessary to add about 4 ½ ounces of soda ash for each pound of trichlor used (if the pH was stable to start with).

#### **5. Lithium Hypo.**

Lithium hypochlorite (chemical formula  $LiClO$ ) is one of the most recently developed forms of chlorine. It is produced by bubbling chlorine gas through a solution of lithium, sodium and potassium sulfates. When dried, the result is free flowing powder that contains 35% available chlorine.

Lithium hypochlorite is calcium free, dust free and nonflammable. It has a long shelf life (it will lose only .1 % of its available chlorine concentration per month) and because it contains no calcium, it rapidly dissolves in water without clouding.

Because it is highly soluble, lithium hypochlorite can be used in vinyl liner pools. When broadcast over the surface of the pool, it will dissolve before it reaches the bottom. It can be used for regular and super chlorination, but because it dissolves so rapidly, it cannot be used in a dry chlorine feeder.

One pound of lithium hypochlorite contains about 1/3 or .35 pound of available chlorine.

The pH of lithium hypo is about 10.7, so it causes an alkaline condition to occur in the pool - that is, it raises the pH. It is therefore necessary to add about 4 ounces of muriatic acid per pound of lithium hydrochlorite if the pH was already in range.

Because lithium hypochlorite does not have any cyanuric acid in it, you must use cyanuric acid separately to keep the chlorine in the pool from being degraded by sunlight, otherwise, in the direct sunlight, 95% of the chlorine could be destroyed in just about two hours.

The overall cost of lithium hypochlorite is the most expensive of the six types of chlorine when you consider the cost of cyanuric acid and muriatic acid to balance the pool water.

## 6. Cal - Hypo.

Cal-Hypo, or Calcium Hypochlorite (chemical formula  $\text{Ca}(\text{ClO})_2$ ) was patented in 1799 and was called “bleaching powder”. It is produced by passing chlorine gas over slaked lime. The resulting powder or granules contain 65% - 10% available chlorine.

Cal-Hypo is stable and can be stored for long periods of time without significant loss in available chlorine content. It is sold in granular form or as 1 inch or 3 inch tablets. It can be used for regular chlorination as well as super chlorination. When used with the **Clearwater Ionizer**, it should be dissolved in water and then added into the skimmer. Failure to do so will result in black stains immediately.

One pound of calcium hypochlorite contains about 2/3 or .65 pounds of available chlorine.

Cal-Hypo is classified as an extreme oxidizer. Except for gas chlorine, all other types of chlorine are classified as oxidizers. Cal-Hypo will support combustion. Avoid mixing Cal-Hypo with soda pop, oil, trichlor or just about anything but water. Mixing with organics will cause a fire. Be careful when sweeping around chemical storage areas. Mixing the dust and spillage of various products together and then putting them into a trash can or dumpster may cause a fire. Clean up spills of products separately.

When adding Cal-Hypo to the pool, it must be broadcast. Avoid concentrating the product in any one area. Cal-Hypo will temporarily cloud the pool, because the calcium can take a long time to dissolve completely. Do not broadcast Cal-Hypo into a vinyl liner pool. It will not dissolve before it hits the bottom. Once on the bottom it will bleach the color out of the vinyl and will weaken the vinyl. You must use a feeder or pre-dissolve it in water and then add to the vinyl liner pool. Depending on local water conditions, using Cal-Hypo will increase the calcium hardness level by an average 3 to 10 parts per million (ppm) per month or about .5 to 2.5 ppm for each pound you add to the pool.

You will need to test calcium hardness more often if Cal-Hypo is added to the pool water on a regular basis.

One pound of Cal-Hypo provides .65 pounds of available chlorine. The pH of Cal-Hypo is 11.8, so it raises the pH. It is necessary to add about 4 ounces of muriatic acid per pound of Cal-Hypo if the pH was already in range.

Outside of chlorine gas, Cal-Hypo is the cheapest type of chlorine used by pool owners. Unfortunately, this type of chlorine can be the most harmful to the pool and its equipment. Because you are adding a lot of calcium to the water, all types of problems can occur. The people at K-Mart that sell HTH (a popular trade name for Cal-Hypo) won't tell you that. High calcium levels when used with the **Clearwater Ionizer** can cause staining.

## HOW TO TEST CHLORINE

There are two types of test kits used to test chlorine in swimming pools.

### 1. OTO.

The OTO test is a colorimetric test that uses a reagent called orthotolidene. The earliest reference to the use of an OTO test was published in 1935. OTO is a white, crystalline material that is normally sold in a hydrochloric acid solution. By itself, OTO will not dissolve in water, so the hydrochloric acid permits it to dissolve and also makes the solution fairly stable, although continued exposure to sunlight can break down OTO and make it ineffective.

In solution, OTO is a clear dye that changes to yellow in the presence of chlorine, bromine, chlorine dioxide, iodine, and ozone and manganese compounds. It also changes color in the presence of minute quantities of gold and in fact is used industrially to detect gold concentrations!

Only in the pool and spa industry is orthotolidene testing known as OTO testing.

To test the sanitizer residual in pool water, you normally add 5 drops of OTO solution to about ½ ounce (15 milliliters) of water. When it comes in contact with sanitizer, the solution will run yellow within 5 seconds. In the case of chlorine, this indicates the presence of free, available chlorine. If combined chlorine is present, the color of the solution will continue to change in intensity. The color comparator lets you translate the intensity of the color into the chlorine concentration in ppm.

At very low levels of total chlorine (.1 to .3 ppm.), the solution will turn a slight straw color. Higher concentrations of chlorine will produce more intense shades of yellow. Very high levels will produce an amber to orange color. Most OTO test kits sold for use in the pool and spa industry have color comparators that read from .3 to 3 or 4 ppm. Some OTO test kits designed specifically for spas have an upper limit of 6 ppm.

The color obtained within the first five seconds of adding the OTO indicates the approximate concentration of free, available chlorine. After that, the combined chlorine begins to react with the reagent. That is why OTO testing is normally referred to as a “Total Chlorine” test. Most experts and virtually all health authorities are concerned only with the residual of free, available chlorine and therefore do not view OTO as a valid test method.

The accuracy of an OTO test can be influenced by the pH of the sample water, the pH of the reagent solution, the alkalinity of the water, the temperature of the water, the cloudiness (turbidity) of the water and the ratio of OTO to chlorine in the sample. Chlorine residuals above 6 ppm cause the color to develop too fast and too intensely for an accurate reading. If you encounter an extremely high residual, the only way to get a good reading is to dilute the sample 50 - 50 with distilled water and double the reading you get with your color comparator.

Remember, OTO reacts in the presence of all oxidizers, so if there is an oxidizer other than chlorine present in the water, you are likely to get a false reading.

OTO may also be used to test total bromine. Manufacturers of OTO bromine test kits include a special color comparator for bromine. You may test for bromine using a chlorine test kit, but you must multiply the results obtained by 2.2, because bromine is 2.2 times heavier than chlorine.

OTO is considered to be a hazardous chemical. Not only is the pH of the OTO solution around 1.5, the OTO is classified as a carcinogen - it has been shown to cause cancer in laboratory studies. For this reason (as well as the fact that OTO is not considered an accurate test for free available chlorine) some health authorities outside of the United States have banned its use.

## **2. DPD.**

The other method to test for chlorine is the DPD test - short for dimethyl-p-phenylenediamine. There is no reason to explain why it is called DPD!

Although DPD is available in a liquid solution, it is most commonly sold in tablet form. DPD is an organic dye that reacts with free chlorine or bromine. It produces shades of pink to red at between 0.4 and 5 parts per million (ppm.) of free chlorine, or 0.9 to 11 ppm of bromine. A chlorine concentration above 5 ppm (or bromine levels above 11 ppm.) DPD produces shades of red. At chlorine levels above 10 ppm or bromine levels of 22 ppm the sanitizer will bleach the color of the DPD dye, producing false low readings.

A DPD test kit normally will measure chlorine residual between 0.4 and 3 ppm. or bromine residual between 0.9 and 6.8 ppm. Most test kits come with two types of reagents, normally marked DPD #1 and DPD #3, although some manufacturers include up to four different reagents in a DPD test kit. The Taylor test kit, the one we recommend, has three.

The DPD #1 reagent is always used to test for free sanitizer only. The proper procedure for performing the test is as follows:

1. Rinse the test cell a few times in the water to be tested, then take a sample... from 18 inches below the surface of the pool or spa.
2. Fill the test cell to the marked fill line, usually 9 milliliters, or about 1/4 of an ounce.
3. Add the DPD reagent (either DPD tablet #1 or liquid #1)
4. Cap the test cell and invert it several times or shake it.
5. Compare the color with the manufacturer's standard color chart.

This will tell you the concentration in ppm. of free chlorine or total bromine.

If you need to know either the concentration of combined chlorine or bromine in the water, or the total amount of chlorine or bromine in the water, you need to add additional reagents to the sample already tested.

Usually, you will use a reagent labeled DPD #3, although some manufacturers include reagents marked DPD #2, #3 and #4 to perform specific tests for monochloramines dichloramines and total chlorine.

Although they are marked "DPD", the substances in the additional packages (or bottles are actually converting reagents that allow the DPD from test #1 to react with both free and combined chlorine or bromine.

In the most common test, the color obtained after the addition of DPD #3 indicates the total chlorine or bromine (both free and combined) in the test solution. To determine the concentration of combined sanitizer only, you simply subtract the reading you obtained on the first test from the reading you got on the second one (Total - Free Combined).

Because DPD reagents usually contain pH buffers, the accuracy of DPD test is generally not influenced by the pH of the sample water.

Temperature can affect the DPD test, because at higher temperatures, combined chlorine and bromine can react with the DPD, producing a false high reading of free sanitizer. Normally, pool temperatures are not high enough to cause this change, but It is a good idea to let spa water samples cool before you test.

Sometimes when you add a DPD #1 tablet or drops, a precipitate will form. This is due to high total hardness of the test sample. Putting the reagent in the test cell first, then adding the water, will prevent this.

DPD contains a substance called aniline, which may cause an allergic reaction and is toxic if absorbed through the skin. When using DPD, do not touch the tablet or liquid with your bare hands. Make sure you place the cap on the sample cell before you invert or shake it.

<b>TYPES OF CHLORINE</b>						
<b>NAME</b>	<b>Elemental Gas Chloride</b>	<b>Sodium Hypochlorite</b>	<b>Lithium Hypochlorite</b>	<b>Calcium Hypochlorite</b>	<b>Sodium Dichloro-s-triazinetriene</b>	<b>Trichlori-s-triazinetriene</b>
<b>Common Name</b>	Gas	Liquid Chlorine	Lithium	Cal-Hypo	Dichlor	Trichlor
<b>Effect on pH</b>	Dramatically lowers	Raises	Raises	Raises	No change	Lowers
<b>Advantages</b>	Least expensive, pure chlorine and nothing else	Inexpensive. Instant chlorine for super Chlorination. Non-Flammable	Dissolves quickly will not cloud water. Safe to handle. Dust Free.	Great for shock or super chlorination. High % of available chlorine	Built in protection from sunlight. Dissolves quickly. No residue. For regular or super chlorination	Dissolves slowly. Longer shelf life. Protected from sunlight. Works in all chlorinators.
<b>Disadvantage</b>	Dangerous & corrosive. Unstable. EPA & DOT licenses required to dispense and transport	Short shelf life. High salt content. Unstable. Dissipates rapidly in heat. Containers may leak.	Expensive. Not protected from sunlight. Lowest chlorine content of dry chlorine compound.	Dangerous to store and handle. Calcium may build up. Clouds water. Unstable.	Possible stabilizer. Build up in commercial pools.	Possible stabilizer buildup in commercial pools. Requires a feeder.

## P. USING AN OXIDIZER

All **Clearwater Pool** and **Spa Ionizers** will need an occasional oxidizer to keep the water sparkling clear.

Commercial pools will need to maintain a small residual of free available chlorine to oxidize the dead matter, algae, bacteria, suntan oils and body oils. All state regulations need to be followed. The NSF (National Sanitation Foundation) has determined that a free available chlorine level of .4 ppm is sufficient to keep the pool in excellent condition when used in conjunction with the ionizer. This will allow the commercial pool owner to reduce his chlorine use by up to 85%. The complaints of chlorine irritation will be eliminated because of no more chloramines in the water.

Residential pools have several options to oxidize the water.

These oxidizers add oxygen to the water. They burn up oils on the surface of the pool as well as organic matter in the water. Oxidizers are especially helpful in destroying the fine debris which the filter fails to remove. This debris, if not removed, will give the water a dull or cloudy appearance. Just as a fire will burn wood, oxidizers in a swimming pool burn organic matter such as pollen, dead algae, dead bacteria, suntan oils and body oils. The result is a fine gray ash that you may see floating in the skimmers. An oxidizer will dissolve a bio-shield that can build up around algae cells, preventing the copper-ions from getting to the algae and killing it.

### Potassium Monopersulfate

Potassium monopersulfate, often called potassium peroxymonosulfate, or “oxidizer” has been the most commonly used non-chlorine oxidizer. Its chemical formula is  $\text{KHSO}_5$  (potassium monopersulfate is not irritating to the skin, even at levels 250 times greater than the amount recommended for oxidation.) This powder will dissolve immediately, and since it contains no chlorine, you can swim in the water without waiting.

Potassium monopersulfate has a pH of approximately 3.0 and when added to the pool water may eliminate or reduce the weekly acid demand.

You should add one pound of potassium monopersulfate per 10,000 gallons weekly in hot weather and every two weeks in warm weather.

The problem with potassium, monopersulfate is its rising cost in the last few years. If your customers desire to use this as their oxidizer, you will need to keep a source available, whether or not you keep it in stock. Some stores that keep it in stock are Leslies Swimming Pool Supplies, with whom you can open an account. They have stores all over the country, or can deliver to you at no extra cost. For more information call 1-800-537-5437 and ask for “Fresh ‘N Clear”. The product is available in several size buckets. Always go with the larger bucket for price savings. Leslie’s has the best pricing, and they are the largest pool store company in the United States.



All pool stores carry this product, but under a different name such as “non-chlorine shock” or some kind of trade name. It is usually listed as potassium monopersulfate, or possibly potassium peroxymonopersulfate in the ingredients.

## LIQUID CHLORINE OR BLEACH

The most cost effective means to oxidize a residential pool is with liquid chlorine or regular household bleach. This chlorine will evaporate quickly (usually within an hour or two) so the swimmer can still enjoy chlorine-free swimming.

Use one quart of liquid chlorine or two quarts of regular household bleach (it’s the same product - but only ½ as strong) per week for every 10,000 gallons in warm weather season, and less frequently during cooler weather.

Make sure you add the chlorine when there are no swimmers in the pool, and, if possible after sunset. Let the water circulate for at least 20 minutes before turning the pump off. Liquid chlorine and liquid bleach are non-stabilized forms of chlorine. Any residual of over 30 ppm of cyanuric acid in the water will cause the chlorine to remain in the water longer, but will generally be out by the next morning.

*Note: liquid chlorine has a very high pH. Always test the pH and total alkalinity when adding anything to the pool first. If you are adding a gallon or more of liquid chlorine, you will need to add about 1 cup of muriatic acid for each gallon of liquid chlorine. This will keep the pH balanced.*

## HYDROGEN PEROXIDE

Hydrogen peroxide, or H<sub>2</sub>O<sub>2</sub>, is another form of oxidizer that can be used with the **Clearwater Ionizer**. This is the same product sold in drug stores as a cleansing agent for cuts, scratches and abrasions of the skin, but is expensive in the small amounts and is only 3% in strength, nowhere near as strong as needed. Hydrogen peroxide is available in pool stores that sell *Baquacil*, as this is one step of the application of this chlorine alternative. This is several times the strength found in drug stores, and is sold in larger containers. Only a small amount is needed with the **Clearwater Ionizer**.

## TRICHLOR TABLET IN SKIMMER

A very simple way to oxidize is by simply adding a 3” trichlor tablet in the skimmer for continuous oxidizing. You can even place it in a sealed “baggy” and puncture a few holes to slowly release a strong chlorine oxidizer. This is an ideal way to oxidize if you are gone from the house for long periods of times.

The actual amount of oxidizer needed and the frequency depends on the season, water temperature, bather load, debris that falls into the pool, the pool’s finish and filter conditions. It is impossible to estimate how much oxidizer that any given pool will need until it has actually been tested. The best rule of thumb is the actual appearance of the water. If it looks dull or hazy, it’s time to oxidize. Do not delay, because the longer you wait to oxidize, the cloudier the water will get. Thus a double, triple or more of a dose would be required. Algae can also start to grow- causing further problems.

If the water gets too cloudy, chlorine is the only option to clear it up, as the cost of potassium monopersulfate is too expensive, and buckets and buckets of it would be required to clear up a very cloudy pool.

## ADD AN OZONE SYSTEM

### ADD OzoneMAX

In May of 2013, Clearwater Enviro introduced their first ozone product called **OzoneMAX**. When added to the copper/silver ionization system, the oxidizer use is greatly reduced. Our first system is a VUV system using a vacuum ultraviolet light. There are two initial models – the OZ-30 and the OZ-60, with the OZ-30 handling pools up to 30,000 gallons and the OZ-60 handling pools up to 60,000 gallons. Our newest model is the OZ-50 and handles up to 50,000 gallons.

By combining the two technologies together, you have the most thorough and effective chlorine alternative system available in the world. Ozone is formed naturally throughout the Earth’s atmosphere when sunlight reacts with oxygen molecules and during lightning storms. Ozone reacts 3,000 times faster than chlorine and is 55 times more powerful. Water clarity is improved and there are no harmful by-products. It will eliminate harmful chloramines.

The system is strongly recommended with the **MineralPURE** system. A venturi injection kit is required to go along with the system.



OZ-60



OZ-30



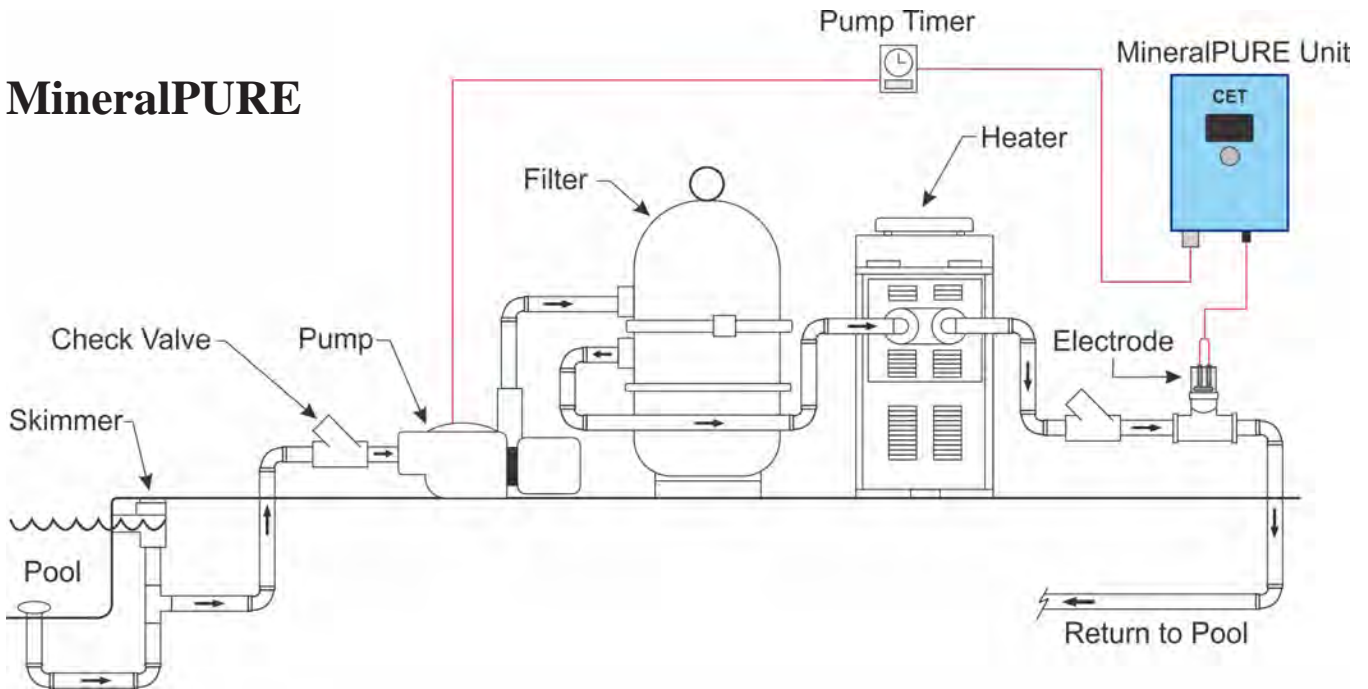
OZ-50



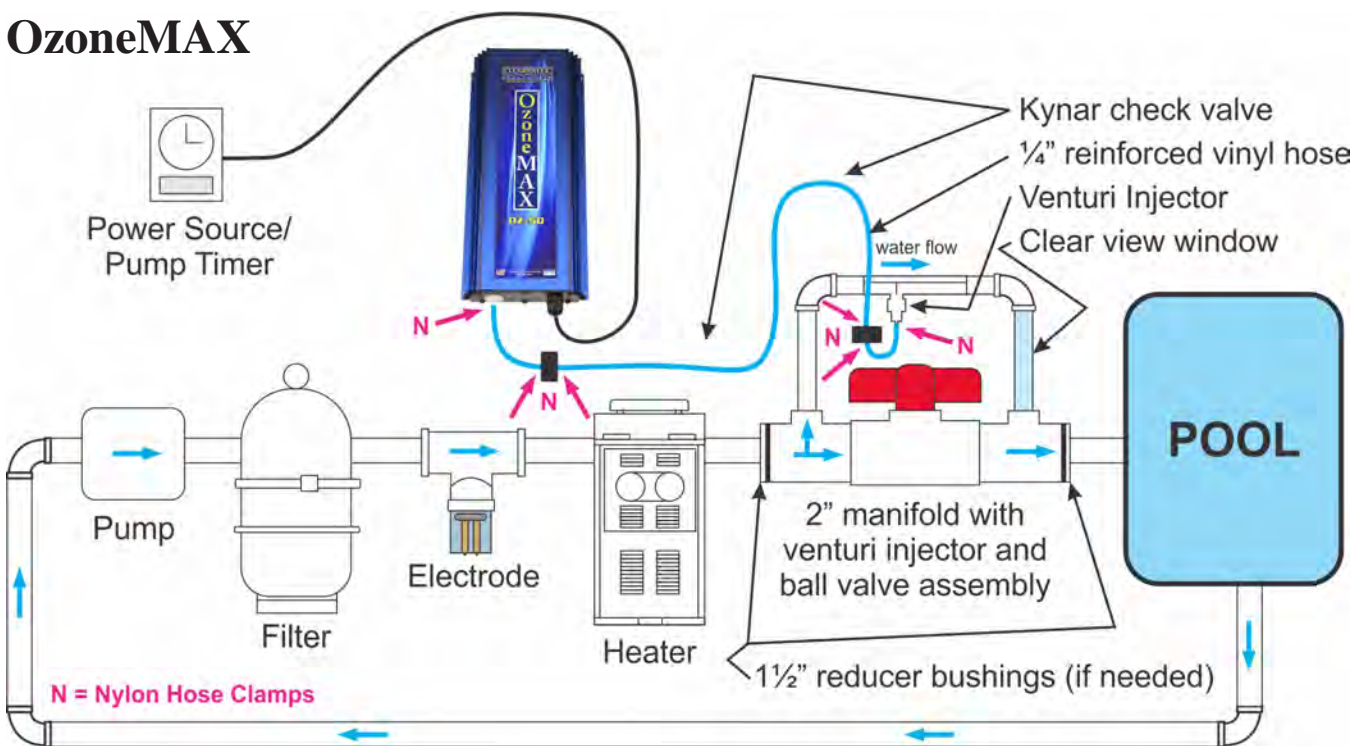
Venturi Injection Kit

# COMBINATION IONIZER / OZONE INSTALLATION

## MineralPURE



## OzoneMAX



# Q. POOL STAIN PREVENTION & REMOVAL

## POOL STAIN PREVENTION

Whenever the ionizer is being added to a marcite/gunite pool, it is very important that a sequestering agent be added to the pool on a regular basis to prevent staining.

There are two types of sequestering agents that we recommend:

A.) ***Pool Stain Treat by United Chemical.*** Follow directions on the container; Generally add 1 pound per 10,000 gallons every 60 days. This will greatly reduce any chance of staining in any type of a pool including marcite/gunite pools. Available from **Clearwater**, many pool stores, or contact United Chemical directly at 1-800-524-5550 or fax (805) 521-1018. Website is- [www.swimpool.com](http://www.swimpool.com)

B.) ***Jack's Magic Product line.*** Follow directions on the container. Available in many pool stores or contact the dealer at 1-800-348-1656 or fax at (727) 532-0250.

## POOL STAIN PREVENTION

These same products can be used if a pool develops staining.

Depending on the seriousness of the stain and the type of pool, a double, triple dose of *Pool Stain Treat* can be added to the pool. Always contact **Clearwater** or call *United Chemical direct* for assistance. Contact *Jack's Magic direct* for use of their stain removers, or see pool store. Make sure they are aware an ionizer is being used.

## NON-DRAIN ACID WASH

If the stains are serious, a "No-Drain Acid Wash" can be done.

- 1.) Turn pool pump off.
- 2.) Add Pool Stain Treat to the pool (several 2 lb. Bottles per 10,000 gallons of water.
- 3.) Add 1 gallon of acid to the pool.
- 4.) Brush the pool at least two times a day. You will see the stains come right up.
- 5.) After 3-5 days of filter off and brushing, add necessary chemicals to bring pH and total alkalinity up.
- 6.) Turn pump back on. Backwash filter several times over the next few days. Keep testing the pH and total alkalinity and balance if necessary. Add chlorine to clear up.

**FOR MORE INFORMATION SEE SECTIONS  
"SEQUESTERING/CHELATING AGENTS"  
"GUNITE STAINS" or "VINYL LINER STAINS".**

## R. PHOSPHATES - the algae source

Although a common component of pool and spa water, phosphates have gone virtually ignored by the pool and spa industry until now. But as water-chemistry experts are discovering, making the effort to remove this key nutrient from the water can control or even eliminate algae blooms in pools and spas. It's a familiar tale of woe: no matter how much shocking, scrubbing, filtering and vacuuming you do, the algae in your customer's pool or spa just keeps coming back. The ionizer can be working at full blast - but you still have algae. Algae can be very persistent. Not only are the microscopic plants remarkably durable and adaptive under a variety of environmental conditions, but wind, rain, debris and even bathers repeatedly reintroduce the algae-causing spores to the pool and spa water.

Pool and spa water also provides algae with a ready food source in the form of phosphates. And while industry chemists have known for years that phosphates play a key role in promoting algae in recreational water, only recently have they considered the idea of removing phosphates to block algae's growth.

How do phosphates get into the pool water? Most household cleaning agents including laundry soap contain phosphates and have been used to clean tile, decks, etc. run off into the pool water as well as fertilizers that run off into the water. Bathers sweat and urine contribute greatly, as well as falling leaves, dirt and other organic debris. Phosphates and other phosphorus-containing compounds are essential building blocks to all living things.

### TESTING OF PHOSPHATES

Test for phosphates by using a simple Phosphate Test Kit. Clearwater recommends using the one made by Vanson (Sea-Klear). Follow the simple directions included with test kit - add 6 drops of Reagent "A", cap, shake, wait 6 minutes, and then add two drops of Reagent "B". Wait one minute, then match to color chart.

Any reading at 125 ppb can cause problems - algae growth and more copper-ion demand.

### ELIMINATING PHOSPHATES

You can eliminate the phosphates by using a product called *Zero Phos*, also made by Vanson. Using the chart on the bottle, add proper amount to the pool by adding it slowly around the entire pool. Run filter at least 24 hours. The water will get cloudy, but clear up in a few days. You will notice the "dead" phosphate on the bottom of the pool. Simply vacuum it up as normal. Re-test the phosphate level. If it still reads high (over 125 ppb), add more *Zero Phos*. Once you get the reading below that level, you will notice the copper-ion level increasing dramatically. Lower ionizer setting if necessary, and test the copper-ion level daily for a few days. You will also notice that it will be more difficult for algae to grow again.

## S. OVERALL WATER BALANCE

The overall water balance ties together pH, total alkalinity and calcium hardness.

Besides being in the recommended range, these factors should be balanced relative to each other. Refer to the Taylor Watergram Wheel in your Taylor test kit. This is sometimes referred to as the Langelier Index method, and will be described in the next chapter. This index takes into consideration water temperature as a major factor in balanced water, but recent studies show that temperature has only a minor influence.

When water is not kept in balance, it will try to balance itself by dissolving or depositing calcium and other solids. Water that corrodes and/or is scale-forming is called unbalanced water while water that causes no damage is balanced.

Corrosive water will etch calcium from the pool walls and metal from the plumbing and fixtures. This “aggressive” water attempts to dissolve concrete and metals. Concrete pitting will take place and a rough surface of an etched pool wall makes an excellent home for stubborn algae. Steel filters and copper heat exchangers will be destroyed over time, and metals (including the copper-ions) can deposit on the pool’s surface.

Scale-forming water will leave hard calcium deposits on pool walls, plumbing and fixtures. This condition also can cause cloudy water and staining as other solids fall out of solution. When pool water becomes over saturated with dissolved substances, especially calcium salts known as calcium carbonates, these substances fall out of solution and settle on pool surfaces. Metal staining can occur when calcium scaling is taking place. The pH and total alkalinity directly affect scaling. A pH reading too high (over 7.8) will cause scaling.

Water balance is so important to maintaining the pool surfaces and parts. It needs to be constantly monitored with test equipment.

# T. LANGELIER INDEX

Back in 1936, Wilfred F. Langelier tried to determine if the water in boilers, cooling towers and heat exchangers was corrosive, neutral or scale-forming. Through experimentation, Langelier discovered that ‘five factors influence calcium carbonate precipitation. They are pH, temperature, alkalinity, calcium hardness and total dissolved solids (TDS).

He, assigned a value to each of these factors and then developed a handy little formula that the values could be plugged into to determine the scale-forming properties of the water. And even though he set out only to find a way to predict whether water would form scale, he also found that his method could predict the water’s ability to corrode.

Langelier modestly called his formula the Langelier Saturation Index, which is usually referred to today simply as the Langelier Index.

A lot has happened to the field of water treatment since 1936, and the Langelier Index has been modified several times to meet specific purposes. This has given rise to a number of other indexes all aimed at accomplishing the same thing as Langelier’s original index - predicting the corrosive or scale-forming tendencies of water.

But no matter which index is used, it can only provide a guideline to water balance –it cannot answer all the questions under all conditions. Langelier ‘ himself modified his original index 10 years later after he developed it because dependable results could not always be predicted.

The Langelier Index takes a value from a table for each of the following four items: temperature, TDS, calcium hardness, and total alkalinity.

We will label them this way:

- A. Temperature
- B. TDS
- C. Calcium hardness
- D. Total alkalinity

# LANGELIER VALUE CHARTS

A.	
Water Temperature (in degrees Fahrenheit)	Value
50 -----	2.35
55 -----	2.27
60 -----	2.21
65 -----	2.14
70 -----	2.08
75 -----	2.02
80 -----	1.97
85 -----	1.91
90 -----	1.86
95 -----	1.80
100 -----	1.74
105 -----	1.69

B.	
TDS in PPM (parts per million)	Value
0 -----	2.35
100 -----	2.27
200 -----	2.21
400 -----	2.14
600 -----	2.08
1000 -----	2.02
1400 -----	1.97
2200 or more -----	1.91

C. and D.	
Calcium Hardness Total Alkalinity (ppm)	Value
10 -----	1.00
20 -----	1.30
30 -----	1.48
40 -----	1.60
50 -----	1.70
60 -----	1.78
70 -----	1.84
80 -----	1.90
90 -----	1.95
100 -----	2.00
120 -----	2.08
140 -----	2.15
150 -----	2.18
200 -----	2.30
250 -----	2.40
300 -----	2.48
350 -----	2.54
400 -----	2.60
450 -----	2.65
500 -----	2.70
550 -----	2.74
600 -----	2.78
700 -----	2.84



After getting the results by testing these factors, obtain a value from the charts provided in this chapter. To obtain the final results, add “A” to “B” together, and then subtract “C” and “D” from that total. The result is a number called the calculated pH, often written pHs. After doing this calculation, there is one more step. You take the actual pH and subtract the calculated pH. The difference is the Langelier Index which can be either a positive or negative number.

If the calculated pH is smaller than the actual pH, the Langelier Index will be a positive number. If it is 0.5 (1/2 pH unit) or above, the Langelier Index indicates that the water is oversaturated and can cause scale.

If the calculated pH is larger than the actual pH, the Langelier Index will be a negative number. If it is -.05 (1/2 pH unit) or below, the Langelier Index indicates that the water is under saturated and can cause corrosion.

If the calculated pH is equal to the actual pH, the Langelier Index will be zero. This indicates that the water is saturated and should have no effect on the pool or equipment. Chances are that you will never find water where the calculated pH is precisely equal to the actual pH. But according to the Langelier Index, if it is within 0.5 (1/2 pH unit) one way or the other, it should not worry you.

## USING THE WATERGRAM WHEEL

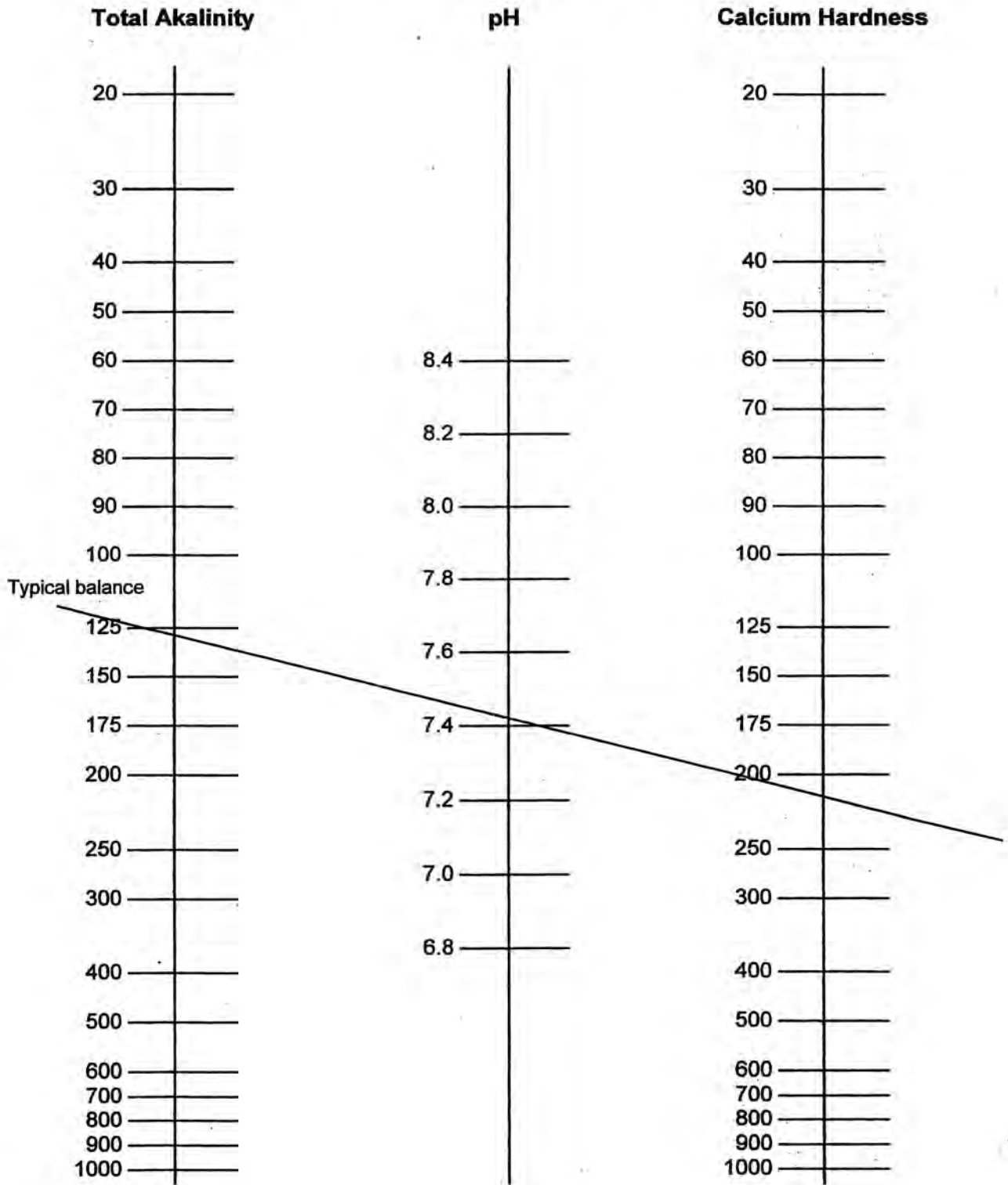
To check water balance by using the Taylor Watergram Wheel, test the pH, total alkalinity, and calcium hardness. Then turn the wheel to set the calcium hardness opposite the total alkalinity. On the other side of the wheel, find the pH that matches the pool water temperature.

This is the perfect pH (ph of saturation). The pool’s pH should be within 0.3 pH units (positive or negative) to ensure that the pool is neither scale-forming nor corrosive. For example, if the pH of saturation was 7.5, the range of 7.2 - 7.6 would be acceptable. If the water’s pH is more than 0.3 pH units above the “perfect” level, the water will tend toward scaling and cloudy water. If the water’s pH is much more than 0.3 pH units below the “perfect” level, the water will tend to be corrosive and could etch the plaster. Since the pH of the pool tends to increase, we recommend a “target” pH slightly below the “perfect” level.

Do not confuse “recommended range” with “water balance”. Without “recommended ranges”, an inexperienced pool operator may decide that a calcium hardness of 60, a total alkalinity of 125 and a pH of 8.0 is balanced and the water should be sparkling clear. In actuality, the water will be in balance, and is neither scale-forming nor corrosive, but the water color and clarity will not be correct. A chlorinated pool would have 80% of its chlorine ineffective, and a **Clearwater** pool would have copper-ions falling out of saturation with pH at 8.0. This is why recommended ranges for each item are provided in addition to the water balance.

On the next page is a typical balance of the Langelier - based in a chart form.

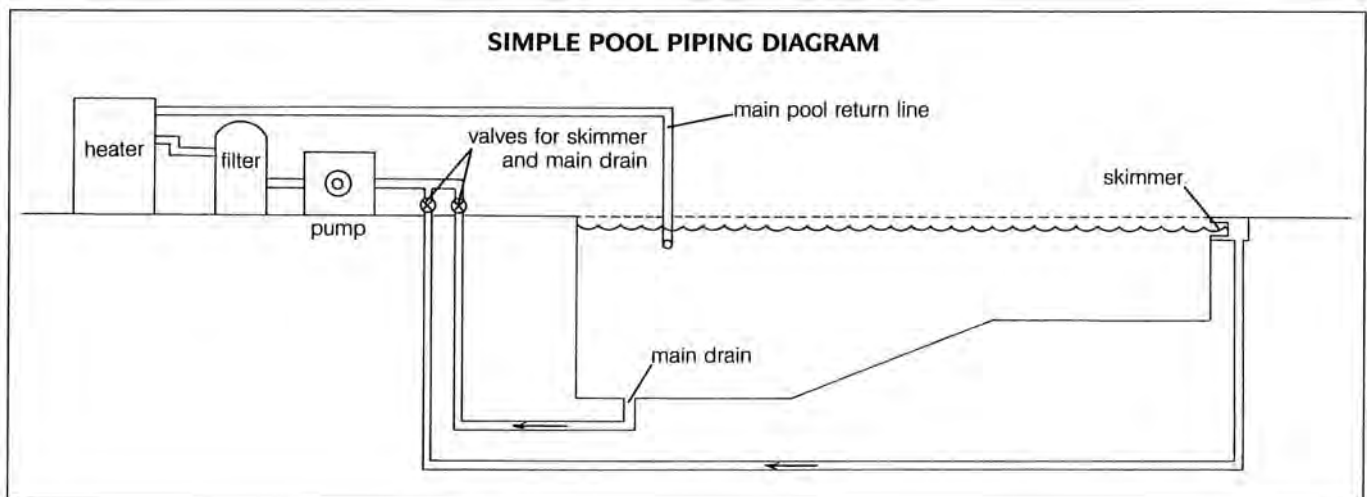
## LANGELIER - BASED WATER BALANCING SCALE



# U. FILTRATION & CIRCULATION

The filtration system is an essential piece of pool equipment. It is usually located close to the pump. Water is pumped from the pool through the pipes into the filter and then returned to the pool. By circulating the water and filtering out large dirt particles and sediment that the chemicals and ions cannot handle, it enables you to use the same pool water over a long period of time.

An efficient filtration system does more than screen out dirt and debris - it also ensures the dispersion and mixture of the copper and silver-ions, as well as the oxidizer. Here is a complete breakdown of everything involved in pool water circulation and filtration:

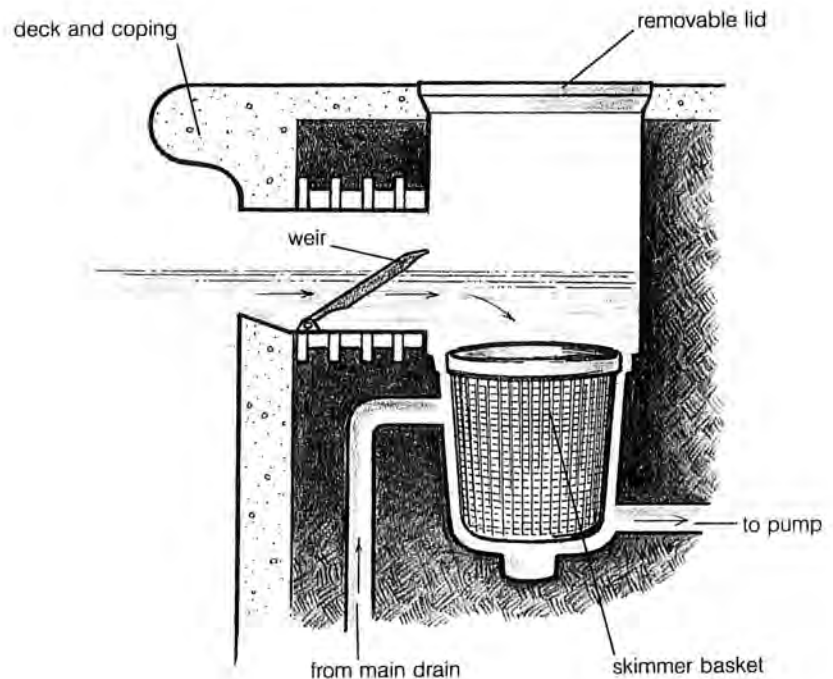


## SKIMMERS

The skimmers remove floating debris from the surface of the water. The debris collect in the basket where it can be removed.

The skimmer may contain a valve for controlling water flow from the bottom drain. Open this valve to get maximum flow from the bottom drain.

*A pool skimmer is designed to collect leaves and other floating debris. This debris is retained in a skimmer basket to prevent it from passing into the filter system and obstructing the lines.*



## BOTTOM DRAIN

The bottom drain pulls water from the bottom of the pool to allow circulation in the deep end. It is not just for draining the pool as the name implies. *It is very important that the bottom drain stays open, unless a pool vacuum system is being used.*

Many pool owners close the bottom drain to increase the skimming action. This limits the filtration since with the bottom drain closed only the top three feet of water are being recirculated and bottom three are stagnant.

If there is no bottom drain, twice a week (or as necessary) drop a vacuum hose into the deep end. Then have it draw water into the skimmer for a minimum of 12 hours. This will help prevent cloudy water.

Of course, if the pool is using a Kreepy Krauly™, Barracuda™, Pool Vac™ or other type of automatic pool vacuuming system, the pool will get excellent circulation even with the bottom drain closed.

## PUMP



**The pump pulls water from the skimmers and bottom drain and forces it through the filter. The pressure gauge is located between the pump and filter and shows the back pressure caused by the filter.**

## VALVES

The water flow from the bottom drain and skimmers is usually controlled by valves just before the pump. Sometimes there is a diverter valve in the bottom of the skimmer. Keep all of the valves open except when vacuuming the pool, in which case, close the valves not connected to the vacuum hose. This will provide stronger suction for vacuuming.

Sometimes, it may be necessary to partially close the valve(s) controlling the skimmers to pull water from the bottom drain. Much more suction is required on the bottom drain and the skimmer(s). Some pools have a single valve which shows 100% to 0% to 100% drain. Do not always rely on these markings. If you have problems with cloudy water, it may be necessary to adjust the valves to pull more water from the bottom drain.

If cloudy water is a problem, temporarily pull water only from the bottom drain. If the pump cavitates (air bubbles form in the strainer basket and the pump creates an unusual sound) open the skimmer valve slightly. To keep clear water it may be necessary to continue operating the pool with the skimmer valve only slightly open.

The importance of proper circulation through the bottom drain cannot be stressed enough: *problems with cloudy water are normally caused by poor pool circulation or filtration.*

## JETS

Filtered water returns to the pool through jets in the pool wall. These are often directional and can be aimed to direct debris toward the skimmers or down to improve overall circulation if a bottom drain is missing.

Some pool jets are designed as part of an automatic pool cleaning device. They keep the water on the bottom of the pool stirred up and allow particles to be filtered out instead of resting on the bottom.

It is important to understand filters and water circulation. What the customer wants is clear water and no work. Many times a customer buys a **Clearwater Ionizer** because he is not happy with his pool. It takes a lot of work and a lot of chemicals and he still can't keep clear water.

This is probably because his filter is not doing a good job. If his filter had been working properly, he may not have bought a **Clearwater** system in the first place.

Pool filters work by forcing water through a filter media with holes smaller than the particles you want to remove. These particles are trapped by the filter until it is cleaned or replaced.

An important part of maintaining clean, clear water is to have good circulation and filtration. Many people try to solve poor water quality problems with chemicals, when the real problem is that they are not operating and maintaining their filters properly. Of course, adding oxidizer and clarifiers will help solve and prevent cloudy water problems, but proper operation of the filtration system is the most important factor in having clear water.

The chart following shows the characteristics of the three basic types of swimming pool filters.

Type	Particle size removed	Cleaning method	Advantages	Disadvantages
Sand (#20 grade silica)	35-50 microns	Backwash	Easy to clean	Not the best filter. Wastes water. Doesn't filter well when sand gets old.
Cartridge woven polyester sheets	15-20 microns	Remove and wash	Good filter, conserves water	Difficult to clean
Diatomaceous Earth (D.E.)	2-4 microns	Backwash filter and periodically change D.E.	Best job filtering	Difficult to clean

Filter problems can cause anything from cloudy water to burned up pumps, so proper maintenance is necessary to keep them operating at their optimum efficiency.

A sand filter that is “dirty” will capture more and smaller debris than a clean filter, So, don't overdo back washing the filter.

Of course, you can do too little. As the filter becomes more and more “plugged up” it increases the back pressure on the pump. This can lead to damage on some pump types, and may even cause leaks or structural failure in some filters.

## BACK PRESSURE

A pressure gauge is provided on most filters which show the back pressure caused by the filter. This pressure is normally allowed to increase by about 8 to 10 psi before the filter needs cleaning or back washing.

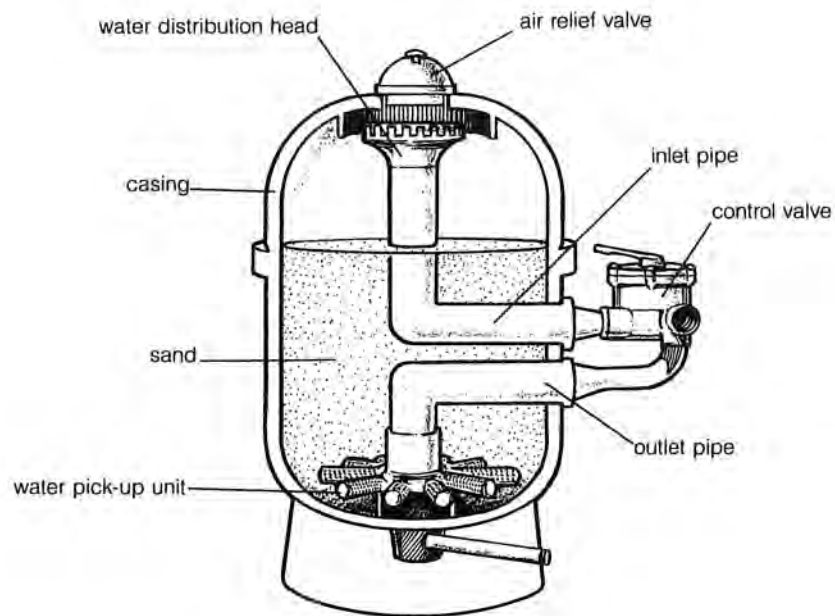
If you backwash too frequently, you will not get good filtration. The filter nameplate will usually provide the recommended pressure ranges for your kind of filter, instructions for operating and cleaning the filter.

## SAND FILTERS

Sand filters were first introduced in the late 1950's. They are characterized by a globe or oblong shaped plastic or fiberglass enclosure. Normally a multi-port valve is located on the front or top of the filter, and a backwash sight glass is located on the backwash line.

Cleaning the sand will eliminate the mud balls, calcium deposits and general mess inside the filter. If the sand is not too old, cleaning the sand will solve the cloudy water problem and eliminate the expense and-work involved in changing the sand.

To clean the sand, turn off the pump and drain as much water as possible from the filter tank. Then pour a bottle of filter cleaner into the pump leaf strainer compartment. Put the valves in the backwash position and run the pump until the filter tank is full. Leave this solution in the filter for about four hours (follow the instructions on the bottle). Then backwash thoroughly. This will get rid of the grease, oils and dirt.



**Dirty pool water enters the high-rate sand filter through the inlet pipe, is sprayed into the sand by the distribution head, is then purified by the sand, and pumped back to the pool clean of dirt and debris**

Follow this with an acid treatment. You can get rid of the calcium buildup on the sand by slowly pouring two quarts (two liters) of acid into the skimmer during the backwash cycle. Sand which is older than two years should be replaced rather than cleaned.

If cleaning the sand doesn't cure the problem or you decide that the sand is too old to bother with cleaning, then you will need to change it. Sand in sand filters should be changed every two years, despite what some pool stores may tell you. Sand will pack tightly together when the rough edges are worn off. This happens after a few years of operation and will allow channeling in the filter. Channeling is the process in which water creates a path through the sand and packs and washes the sand out to form rivers through the sand and packs and washes the sand out to form rivers through the sand. This defeats the filtering effect of the sand.

Changing the filter sand will require #20 grade silica sand or the type and amount as shown on the sand filter nameplate. If too much sand or too little sand or if the wrong type of sand is used, the filter will not work properly. It is very important to use "filter" sand and not "play" sand or river sand.

When changing sand, be careful not to break the laterals or fingers in the bottom of the filter. Fill the filter with water before adding sand to help distribute the sand and protect the laterals from the force of the sand hitting the bottom. Filter sand constantly found in the bottom of the pool is a characteristic sign of a broken lateral in the sand filter.

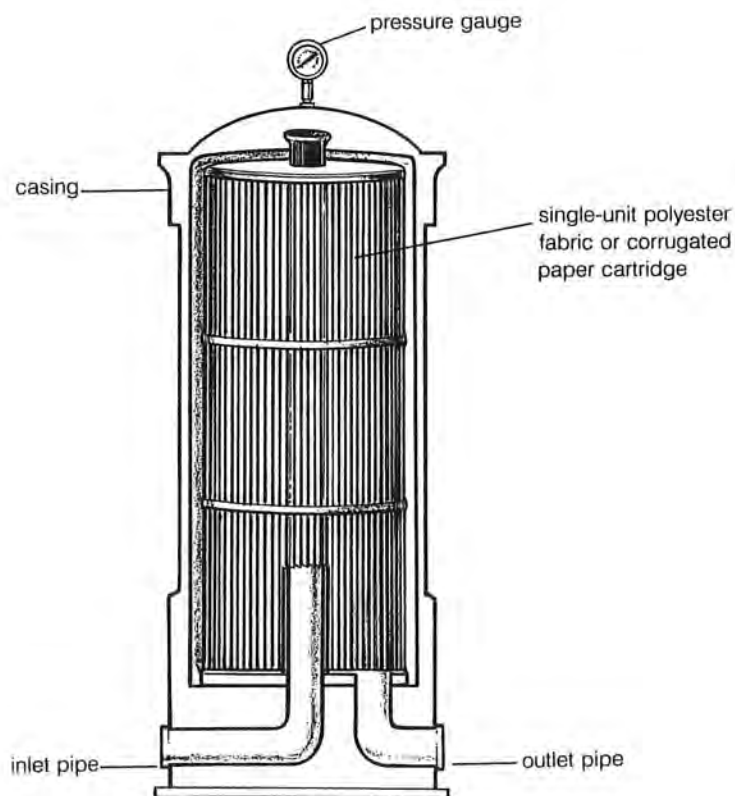
We find that most distributors change the sand on about one pool out of ten. Routinely changing the sand any time the sand is more than two to three years old could solve a lot of potential problems. If you change the sand in filters very often, you will find a device called a “**Sand-Vac**” will make the job much easier.

Cloudy water can also be caused by a defective **spider gasket** in the **multi-port valve**. This can allow some water to bypass the filter entirely.

## CARTRIDGE FILTER

Cartridge filters have now been around for about 15 years or so. They should be cleaned by hosing off the outside of the cartridge. Periodic soaking of the cartridge in cartridge filter cleaner should be done to remove scale, especially in areas with hard water. Any cartridge with a hole, (no matter how small) should be replaced. Even a hole the size of a pencil point will cause cloudy water.

Cartridge filters are commonly used in spas and hot tubs and they are generally neglected by their owners. They can cause a musty smell after converting to the **Clearwater** pool system if they are not cleaned regularly.



**A cartridge filter employs a pleated polyester cloth or special corrugated paper cartridge (or cartridges) to provide maximum filter surface area.**



## D. E. FILTERS

Diatomaceous earth filters are characterized by vertical stainless steel enclosures which separate in the middle, usually by a constriction band. These filters may have provisions for back washing or bumping. They first appeared shortly after the end of World War II.

In general, there will be one or more cloth surfaces in the filter with a white powder (D.E.) coated to this surface. The dirt collects on this white powder. D.E. filters can be partially cleaned by back washing the filter and adding a little extra D.E. per the manufacturer's instructions, if so equipped.

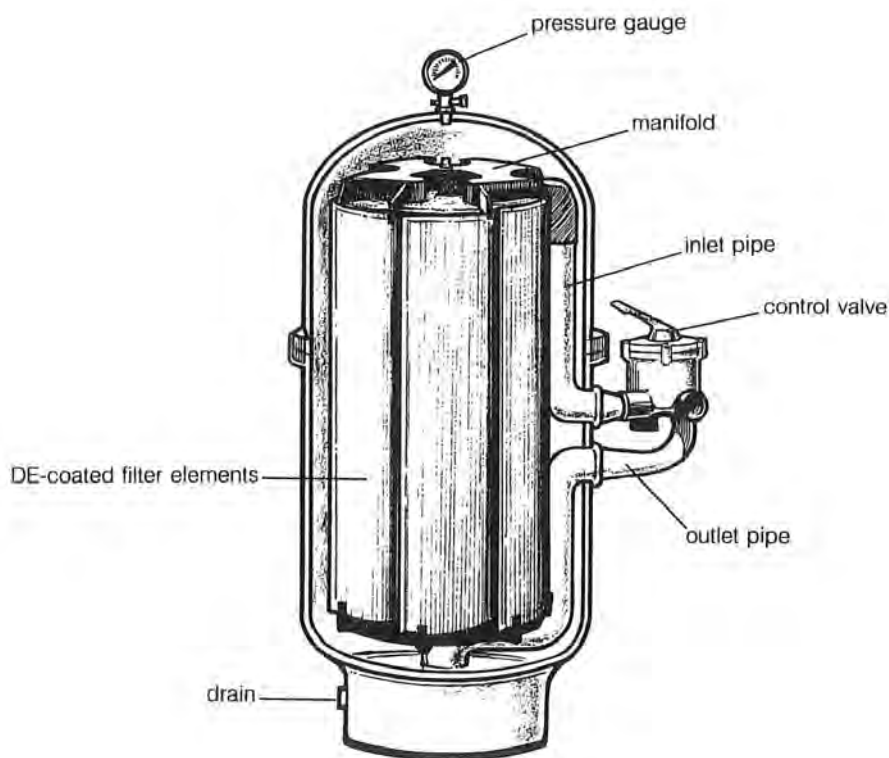
If it is a "bump" type D.E. filter, you can bump the filter per the manufacturer's instructions.

To completely clean a D.E. filter you have to disassemble the filter and hose it down.

With the filter clean and reassembled and the pump running, mix the manufacturer's recommended amount of D.E. in a bucket and pour into the skimmer. This will re-coat the filter.

As with the cartridge filter, any holes are intolerable and will cause cloudy water. Any accumulation of D.E. in the bottom of the filter must also be removed.

The main problem with a backwash or bump type D.E. filter is that people take the easy way out too many times by just back washing or bumping and adding more D.E. If you are having a problem with cloudy water and have a D.E. filter of any kind, disassemble the filter and thoroughly clean it. This is very important. The D.E. material can become caked on the filter and become ineffective.



# II.

# MAINTENANCE & TROUBLESHOOTING

# A. SIZING THE SYSTEM

When installing the **Clearwater** system, always make sure it is large enough for the application. The worst thing to do is sell an ionizer on a large commercial pool, only to find it not powerful enough. The maximum capacities on the product specification sheets are a good rule of thumb, but there are some other considerations. Always contact **Clearwater's** corporate office for sizing on large units or units in warm weather locations.

## CLIMATE

When sizing a unit, the most important factor is climate. If the pool is in a hot weather area (like Acapulco or Indonesia), you may want to double the size of the unit. For example, a 150,000 gallon pool should get a CS-300 unit (or a unit that is normally rated to handle 300,000 gallons). Water temperature makes a huge difference, as algae will grow easier the warmer the water is. Water temperatures that approach 90 degrees or more should be double sized.

## METAL PLUMBING

We recommend that the system for any metal plumbed installation be oversized to the next large system, because the metal pipes may absorb some of the copper and silver-ions. It is also important that the electrodes be installed as close to the pool water return outlet as possible. When there is metal plumbing, we also recommend that a convenient section of the metal pipe be removed and replaced with PVC to allow at least two feet of PVC on both sides of the electrode chambers. If this can't be done, there might be problems obtaining an ideal copper-ion level.

## SALT WATER POOLS

Salt or sea water pools will work with the **Clearwater** ionizer (RC-50) with no adjustments to the electrodes, the world's first ionizer to do so. However, if you are installing the unit on a saltwater pool, please let **Clearwater** know, as we need to make an adjustment on the circuit board. The units will work fine, but the electrodes will wear out much faster than normal, and will need frequent cleaning. The silver will not stay in the water due to the salt content, so it is advised to maintain small chlorine residual at all times if possible.

## WATER LOSS

If a pool is losing an abnormal amount of water (intentionally or otherwise), the sizing of the ionizer may have to be increased. Questions that need to be addressed are:

- 1.) Is the pool leaking?
- 2.) Does the cutter or skimmers drain to waste instead of recirculating?
- 3.) Is the pool back washed excessively?
- 4.) Is the pool drained periodically?

## DETERMINING THE PROPER UNIT

*Clearwater manufactures several models to fit any size pool or spa:*

### SPA-1R

The SPA-1R unit is designed to handle up to 1,000 gallons. It is designed in a weatherproof enclosure and has the electrodes in a clear chamber for easy viewing.

### R-40

The R-40 unit is designed to handle up to 40,000 gallons of water, or 20,000 in very warm weather climates like Florida or Arizona. This is a very basic unit that is not digital and has no digital readout displays.

### RC-50

The RC-50 is a copper/silver ionization system. It was released in 2007 and has a micro-processor that features a large LCD display window for easy monitoring. The unit also comes with a built-in **ScaleBlaster** unit to remove lime scale deposits in the pool. This unit will automatically work on 110/220 VAC with no adjustments and works on low TDS and salt water with no problems. The model can handle any pool up to 50,000 gallons.

## COMMERCIAL UNITS - CS SERIES

Clearwater stocks four models of the commercial line - the CS-75, CS-150, CS-225, CS-300, CS-450 and the CS-600. The number after the letters “CS” determines how many gallons the unit can handle X 1,000. For example, the CS-75 can handle 75,000 gallons of water; the CS-150 can handle 150,000 gallons and so on.

There are additional sizes available, as the microchip can be programmed to handle 32 circuit boards. The first board is the “Master” and any board after that is called a “Slave”. A CS-150 has one master and one slave. The CS-300 has one master and three slaves. Each board is capable of delivering 1 amp of power or be able to handle 75,000 gallons of water.

# MineralPURE®

*The Healthy Alternative to Chlorine*

*Residential Pool Ionization System & Electronic Decaler System  
Model # RC-50*



*Premium Model - Handles up to 50,000 gallons*

**SPECIFICATION SHEET**

# RC-50 IONIZER SPECIFICATION SHEET

## Water Specifications

**POOL SIZE:** up to 50,000 U.S. gallons

**IONIZATION METHOD:** electrolysis of copper or copper/silver alloy electrodes

**ELECTRODE CHAMBER:** 2" black tee with bushings for 2" or 1 1/2" PVC pipe

**ELECTRODE:** one set 3" long, comprised of copper (CLE-11)  
or optionally available copper/silver alloy (CLE-42 or CLE-44)

<b>HEAD LOSS:</b>	<b>Flow Rate</b>	<b>Total Head Loss (psi)</b>
	25 gpm	0.06 psi
	50 gpm	0.21 psi

**Hydrostatic Pressure:** Maximum Recommended Pressure: 50PSI

**Ion Production:** With the output set to: 300mA this ionizer produces 215mg of copper ions per hour  
600mA this ionizer produces 430mg of copper ions per hour

These measurements were made with the following conditions:

Electrode Used: CLE-11

Water Temperature: 72.7 °F

Total Chlorine: 0

pH: 7.45

TDS: 347 mg/L

Hardness: 215 mg/L

Total Alkalinity: 85 mg/L

## Electrical Specifications

**INPUT VOLTAGE:** 90 to 264 VAC, at 47 to 63 HZ, auto switching

**INPUT CURRENT:** 300 mA rms at 120VAC

150 mA rms at 240VAC

**INPUT POWER:** up to 20 Watts

**OUTPUT VOLTAGE:** 2VDC to 20VDC, Auto Ranging

**OUTPUT CURRENT:** Adjustable in 5mA increments, 0 TO 600mA DC

**CIRCUIT PROTECTION:** internal fuse and input line surge protection to IEC 61000-4-5, level 3

**FUSES:** 1 ea 2A Slo Acting, Cartridge Style, 250VAC, 5x20mm

1 ea 4A Slo Acting, Cartridge Style, 250VAC, 5x20mm

## Mechanical Specifications

**ENCLOSURE:** weather resistant NEMA 4 rated high impact corrosion resistant thermoplastic with hinged polycarbonate cover, includes mounting brackets

**ENCLOSURE DIMENSIONS:** 8.44" x 8.44" x 4.88"

**SHIPPING WEIGHT:** 12 lbs

**CARTON DIMENSIONS:** 22 1/4" x 11 1/4" x 6 5/16"

## Other Specifications

**CERTIFICATIONS:** UL Listed File Number E354947,

NSF tested to NSF/ANSI Standard 50-2011

**OPERATING TEMPERATURE RANGE:** 32 to 110 degrees Fahrenheit

**WARRANTY:** 5 years, parts and labor - excluding electrodes



# MineralPURE<sup>®</sup>

*The Healthy Alternative to Chlorine*

*Residential Ionization System  
Model # SPA-1R*



*Premium Model - Handles up to 1,000 gallons*

## SPECIFICATION SHEET

# SPA-1R IONIZER SPECIFICATION SHEET

## Water Specifications

**POOL SIZE:** up to 1,000 U.S. gallons

**IONIZATION METHOD:** electrolysis of copper or copper/silver alloy electrodes

**ELECTRODE CHAMBER:** 2" schedule 40 tee with bushings for 2" or 1 1/2" PVC pipe

**ELECTRODE:** one set 1.5" long, comprised of copper (CLE-01)  
or 90/10 copper/silver alloy (CLE-50)

<b>HEAD LOSS:</b>	<b>Flow Rate</b>	<b>Total Head Loss (psi)</b>
	25 gpm	0.06 psi
	50 gpm	0.21 psi

**Hydrostatic Pressure:** Maximum Recommended Pressure: 50PSI

**Ion Production:** With the output set to: 25mA this ionizer produces 18mg of copper ions per hour  
50mA this ionizer produces 36mg of copper ions per hour

These measurements were made with the following conditions:

Electrode Used: CLE-01

Water Temperature: 72.7 °F

Total Chlorine: 0

pH: 7.45

TDS: 347 mg/L

Hardness: 215 mg/L

Total Alkalinity: 85 mg/L

## Electrical Specifications

**INPUT VOLTAGE:** 115 VAC or 230 VAC, manually switched from inside control box

**INPUT CURRENT:** 100 mA rms at 115 VAC  
50 mA rms at 230 VAC

**INPUT POWER:** 5 Watts

**OUTPUT VOLTAGE:** 18 VDC

**OUTPUT CURRENT:** Adjustable from 0 TO 50mA DC

**CIRCUIT PROTECTION:** internal fuse and input MOV line surge protection

**FUSES:** 1 ea .25 Amp Fast Acting, Cartridge Style, 250VAC, 5x20mm  
Radio Shack Part Number 270-1046 (use 270-1061 if other is unavailable)

## Mechanical Specifications

**ENCLOSURE:** weather resistant NEMA 4 rated high impact corrosion resistant thermoplastic with hinged polycarbonate cover, includes mounting brackets

**ENCLOSURE DIMENSIONS:** 6.54" x 6.54" x 4.82"

**SHIPPING WEIGHT:** 5.8 lbs

**CARTON DIMENSIONS:** 12" x 11" x 6"

## Other Specifications

**OPERATING TEMPERATURE RANGE:** 32 to 110 degrees Fahrenheit

**WARRANTY:** 5 years, parts and labor - excluding electrodes



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# MineralPURE<sup>®</sup>

*The Healthy Alternative to Chlorine*

*Residential Pool Ionization System  
Model # R-40*



*Handles up to 40,000 gallons*

**SPECIFICATION SHEET**

# R-40 IONIZER SPECIFICATION SHEET

## Water Specifications

**POOL SIZE:** up to 40,000 U.S. gallons

**IONIZATION METHOD:** electrolysis of copper or copper/silver alloy electrodes

**ELECTRODE CHAMBER:** 2" schedule 40 tee with bushings for 2" or 1 1/2" PVC pipe

**ELECTRODE:** one set 3" long, comprised of copper (CLE-02)  
or optionally available 90/10 copper/silver alloy (CLE-51)

<b>HEAD LOSS:</b>	<b>Flow Rate</b>	<b>Total Head Loss (psi)</b>
	25 gpm	0.06 psi
	50 gpm	0.21 psi

**Hydrostatic Pressure:** Maximum Recommended Pressure: 50PSI

**Ion Production:** With the output set to: 250mA this ionizer produces 179mg of copper ions per hour  
500mA this ionizer produces 358mg of copper ions per hour

These measurements were made with the following conditions:

Electrode Used: CLE-02

Water Temperature: 72.7 °F

Total Chlorine: 0

pH: 7.45

TDS: 347 mg/L

Hardness: 215 mg/L

Total Alkalinity: 85 mg/L

## Electrical Specifications

**INPUT VOLTAGE:** 115 VAC or 230 VAC, manually switch from inside of control box

**INPUT CURRENT:** 220 mA rms at 115 VAC  
110 mA rms at 230 VAC

**INPUT POWER:** 13 Watts

**OUTPUT VOLTAGE:** < 20 VDC

**OUTPUT CURRENT:** Adjustable in 6 increments from 0 TO 500mA DC

**CIRCUIT PROTECTION:** internal fuse and input MOV line surge protection

**FUSES:** 1 ea .25 Amp Fast Acting, Cartridge Style, 250VAC, 5x20mm  
Radio Shack Part Number 270-1046 (use 270-1061 if other is unavailable)

## Mechanical Specifications

**ENCLOSURE:** weather resistant NEMA 4 rated high impact corrosion resistant thermoplastic with hinged polycarbonate cover, includes mounting brackets

**ENCLOSURE DIMENSIONS:** 6.54" x 6.54" x 4.82"

**SHIPPING WEIGHT:** 7.6 lbs

**CARTON DIMENSIONS:** 12" x 11" x 6"



## Other Specifications

**OPERATING TEMPERATURE RANGE:** 32 to 110 degrees Fahrenheit

**WARRANTY:** 5 years, parts and labor - excluding electrodes



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CLM-252

# CLEARWATER™

P O O L S Y S T E M S

*The Healthy Alternative to Chlorine*

*Model # CS-75*



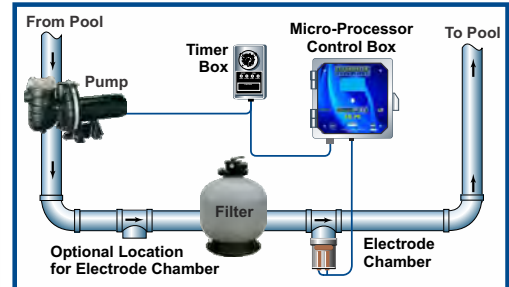
*Premium Model — handles up to 75,000 gallons*

**MineralPURE®**

**SPECIFICATION SHEET**

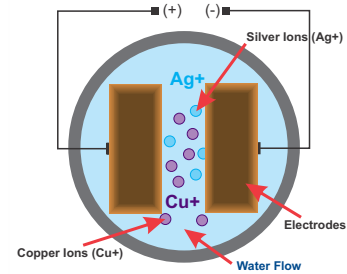
# How MineralPURE Works

The **MineralPURE** purification system consists of a state-of-the-art micro-processor control box and a scientifically designed set of **electrodes** composed of copper or copper/silver alloy that are set slightly apart from one another. Water is passed through a specially designed **flow cell chamber** that houses the electrodes. The control box works by generating a precise, low voltage, DC current (at milliamp levels) to the electrodes.



Basically, the current causes some of the outermost atoms of the electrodes to lose an electron, thus becoming positive ions. While the water is running through the chamber, many of these ions are swept away before they can reach the other side of the electrodes. As a result, the mineral ions are dispersed into the body of water that is being purified.

The greatest benefit of mineral ionization is that the ions remain in the water providing a residual protection. They provide **long-term, nontoxic purification** and prevent against recontamination. Unlike most other types of sanitizers, the mineral ions remain in the water until they flocculate, or form masses with algae and bacteria and then become large enough to be removed by the filtering equipment.



When the "used" mineral ions are removed, the microprocessor control box is always producing new mineral ions to continuously sanitize the water.



## CS-75 IONIZER SPECIFICATION SHEET

**POOL SIZE:** up to 75,000 U.S. gallons.

**INPUT VOLTAGE:** 90 to 264VAC, at 47 to 63 HZ, auto switching

**INPUT CURRENT and WATTAGE:** With electrode output set to 1000mA (max)

375mA at 120VAC (45 Watts), 350mA at 240VAC (84 Watts)

**OUTPUT VOLTAGE:** 2.5VDC to 20VDC, Auto Ranging, Dynamically Adjusted

**OUTPUT CURRENT:** Adjustable in 5mA increments

0 to 1000mA DC in analog mode (each output)

0 to 1000mA DC average in pulse width modulation mode (each output)

**CIRCUIT PROTECTION:** internal input fuse, both on high side and low side, input line spike/surge immunity to IEC 1000-4-5, level 3

**FUSES:** F1 - 2A, 250VAC, 5x20mm, Slow Blow / F2 - 4A, 250VAC, 5x20mm, Slow Blow

**IONIZATION METHOD:** electrolysis of copper or copper/silver alloy electrodes by a microprocessor control circuit

**ELECTRODE:** One 6" set of electrodes, comprised of copper (CLE-05), copper/silver alloy electrodes are available - 7" long 90/10 copper/silver alloy electrodes (CLE-20), 6" long 80/20 copper/silver alloy electrodes (CLE-14), contact **Clearwater Enviro Tech** for details.

**ELECTRODE CHAMBER:** Customers choice between 3" or 4" tees or crosses

**ENCLOSURE:** weather resistant NEMA 4X (IP65) rated, UL 94 Flame Rating, UL UV rated, high impact corrosion resistant thermoplastic with hinged polycarbonate cover

**ENCLOSURE DIMENSIONS:** 8" x 8" x 4"

**OPERATING TEMPERATURE RANGE:** 32 - 110 degrees F

**WARRANTY:** 3 years, parts and labor - excluding electrodes

**SHIPPING WEIGHT:** 16 lbs.

**CARTON DIMENSIONS:** 24" x 12" x 12"

### HEAD LOSS:

When using:

CLF-49 - 3" Sch. 80 Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-51 - 3" Sch. 80 Cross Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-48 - 4" Sch. 80 Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-52 - 4" Sch. 80 Cross Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

**HYDROSTATIC PRESSURE:** Maximum Recommended Pressure: 50PSI

**USING THE CLE-05 ELECTRODE:** This ionizer with the output set to 50% (500mA) produces 358 mg of copper per hour. When set to 100% (1000mA) produces 716 mg of copper per hour.



### ION PRODUCTION WITH THE FOLLOWING WATER CONDITIONS:

Water Temperature: 72.7 °F

Total Chlorine: None

pH: 7.45

TDS: 347 mg/L

Hardness: 215 mg/L

Total Alkalinity: 85 mg/L

Manufactured by Clearwater Enviro Technologies, Inc. MineralPURE is a registered trademark of CET. © 2016

# CLEARWATER™

P O O L S Y S T E M S

*The Healthy Alternative to Chlorine*

*Model # CS-150*



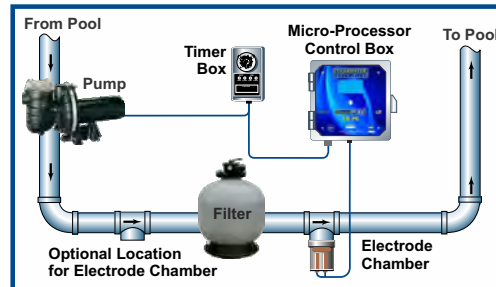
*Premium Model — handles up to 150,000 gallons*

**MineralPURE®**

**SPECIFICATION SHEET**

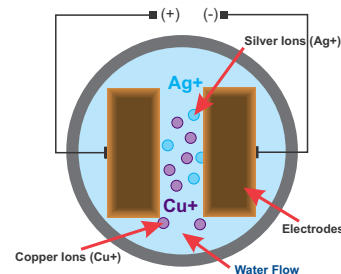
# How MineralPURE Works

The MineralPURE purification system consists of a state-of-the-art micro-processor control box and a scientifically designed set of **electrodes** composed of copper or copper/silver alloy that are set slightly apart from one another. Water is passed through a specially designed **flow cell chamber** that houses the electrodes. The control box works by generating a precise, low voltage, DC current (at milliamp levels) to the electrodes.



Basically, the current causes some of the outermost atoms of the electrodes to lose an electron, thus becoming positive ions. While the water is running through the chamber, many of these ions are swept away before they can reach the other side of the electrodes. As a result, the mineral ions are dispersed into the body of water that is being purified.

The greatest benefit of mineral ionization is that the ions remain in the water providing a residual protection. They provide **long-term, nontoxic purification** and prevent against recontamination. Unlike most other types of sanitizers, the mineral ions remain in the water until they flocculate, or form masses with algae and bacteria and then become large enough to be removed by the filtering equipment.



When the "used" mineral ions are removed, the microprocessor control box is always producing new mineral ions to continuously sanitize the water.



## CS-150 IONIZER SPECIFICATION SHEET

**POOL SIZE:** up to 150,000 U.S. gallons.

**INPUT VOLTAGE:** 90 to 264VAC, at 47 to 63 HZ, auto switching

**INPUT CURRENT and WATTAGE:** With electrode output set to 1000mA (max)

550mA at 120VAC (66 Watts), 500mA at 240VAC (120 Watts)

**OUTPUT VOLTAGE:** 2.5VDC to 20VDC, Auto Ranging, Dynamically Adjusted

**OUTPUT CURRENT:** Adjustable in 5mA increments

0 to 1000mA DC in analog mode (each output)

0 to 1000mA DC average in pulse width modulation mode (each output)

**CIRCUIT PROTECTION:** internal input fuse, both on high side and low side, input line spike/surge immunity to IEC 1000-4-5, level 3

**FUSES:** F1 - 2A, 250VAC, 5x20mm, Slow Blow / F2 - 4A, 250VAC, 5x20mm, Slow Blow

**IONIZATION METHOD:** electrolysis of copper or copper/silver alloy electrodes by a microprocessor control circuit

**ELECTRODE:** Two sets of electrodes, comprised of copper (CLE-05), copper/silver alloy electrodes are available - 7" long 90/10 copper/silver alloy electrodes (CLE-20), 6" long 80/20 copper/silver alloy electrodes (CLE-14), contact **Clearwater Enviro Tech** for details.

**ELECTRODE CHAMBER:** Customers choice between 3" or 4" tees or crosses

**ENCLOSURE:** weather resistant NEMA 4X (IP65) rated, UL 94 Flame Rating, UL UV rated, high impact corrosion resistant thermoplastic with hinged polycarbonate cover

**ENCLOSURE DIMENSIONS:** 8" x 10" x 6"

**OPERATING TEMPERATURE RANGE:** 32 - 110 degrees F

**WARRANTY:** 3 years, parts and labor - excluding electrodes

**SHIPPING WEIGHT:** 28 lbs.

**CARTON DIMENSIONS:** 19" x 16" x 10"

### HEAD LOSS:

When using:

CLF-49 - 3" Sch. 80 Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-51 - 3" Sch. 80 Cross Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-48 - 4" Sch. 80 Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-52 - 4" Sch. 80 Cross Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

**HYDROSTATIC PRESSURE:** Maximum Recommended Pressure: 50PSI

**USING THE CLE-05 ELECTRODE:** This Ionizer with the output set to 50% (500mA) produces 716 mg of copper per hour. When set to 100% (1000mA) produces 1.432 g of copper per hour.



### ION PRODUCTION WITH THE FOLLOWING WATER CONDITIONS:

Water Temperature: 72.7 °F

Total Chlorine: None

pH: 7.45

TDS: 347 mg/L

Hardness: 215 mg/L

Total Alkalinity: 85 mg/L

# CLEARWATER™

P O O L S Y S T E M S

*The Healthy Alternative to Chlorine*

*Model # CS-225*



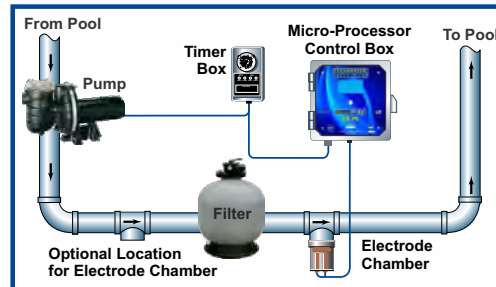
*Premium Model — handles up to 225,000 gallons*

**MineralPURE®**

**SPECIFICATION SHEET**

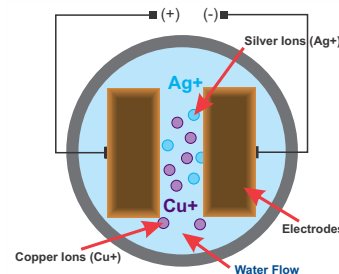
# How MineralPURE Works

The MineralPURE purification system consists of a state-of-the-art micro-processor control box and a scientifically designed set of **electrodes** composed of copper or copper/silver alloy that are set slightly apart from one another. Water is passed through a specially designed **flow cell chamber** that houses the electrodes. The control box works by generating a precise, low voltage, DC current (at milliamp levels) to the electrodes.



Basically, the current causes some of the outermost atoms of the electrodes to lose an electron, thus becoming positive ions. While the water is running through the chamber, many of these ions are swept away before they can reach the other side of the electrodes. As a result, the mineral ions are dispersed into the body of water that is being purified.

The greatest benefit of mineral ionization is that the ions remain in the water providing a residual protection. They provide **long-term, nontoxic purification** and prevent against recontamination. Unlike most other types of sanitizers, the mineral ions remain in the water until they flocculate, or form masses with algae and bacteria and then become large enough to be removed by the filtering equipment.



When the "used" mineral ions are removed, the microprocessor control box is always producing new mineral ions to continuously sanitize the water.



## CS-225 IONIZER SPECIFICATION SHEET

**POOL SIZE:** up to 225,000 U.S. gallons.

**INPUT VOLTAGE:** 90 to 264VAC, at 47 to 63 HZ, auto switching

**INPUT CURRENT and WATTAGE:** With electrode output set to 1000mA (max)

1A at 120VAC (120 Watts), 800mA at 240VAC (192 Watts)

**OUTPUT VOLTAGE:** 2.5VDC to 20VDC, Auto Ranging, Dynamically Adjusted

**OUTPUT CURRENT:** Adjustable in 5mA increments

0 to 1000mA DC in analog mode (each output)

0 to 1000mA DC average in pulse width modulation mode (each output)

**CIRCUIT PROTECTION:** internal input fuse, both on high side and low side, input line spike/surge immunity to IEC 1000-4-5, level 3

**FUSES:** F1 - 2A, 250VAC, 5x20mm, Slow Blow / F2 - 4A, 250VAC, 5x20mm, Slow Blow

**IONIZATION METHOD:** electrolysis of copper or copper/silver alloy electrodes by a microprocessor control circuit

**ELECTRODE:** Three sets of electrodes, comprised of copper (CLE-05), copper/silver alloy electrodes are available - 7" long 90/10 copper/silver alloy electrodes (CLE-20), 6" long 80/20 copper/silver alloy electrodes (CLE-14), contact **Clearwater Enviro Tech** for details.

**ELECTRODE CHAMBER:** Customers choice between 3" or 4" tees or crosses

**ENCLOSURE:** weather resistant NEMA 4X (IP65) rated, UL 94 Flame Rating, UL UV rated, high impact corrosion resistant thermoplastic with hinged polycarbonate cover

**ENCLOSURE DIMENSIONS:** 8" x 10" x 6"

**OPERATING TEMPERATURE RANGE:** 32 - 110 degrees F

**WARRANTY:** 3 years, parts and labor - excluding electrodes

**SHIPPING WEIGHT:** 40 lbs.

**CARTON DIMENSIONS:** 18" x 18" x 18"

### HEAD LOSS:

When using:

CLF-49 - 3" Sch. 80 Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-51 - 3" Sch. 80 Cross Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-48 - 4" Sch. 80 Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-52 - 4" Sch. 80 Cross Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

**HYDROSTATIC PRESSURE:** Maximum Recommended Pressure: 50PSI

**USING THE CLE-05 ELECTRODE:** This Ionizer with the output set to 50% (500mA) produces 1.074 g of copper per hour. When set to 100% (1000mA) produces 2.148 g of copper per hour.



### ION PRODUCTION WITH THE FOLLOWING WATER CONDITIONS:

Water Temperature: 72.7 °F

Total Chlorine: None

pH: 7.45

TDS: 347 mg/L

Hardness: 215 mg/L

Total Alkalinity: 85 mg/L



# CLEARWATER™

P O O L S Y S T E M S

*The Healthy Alternative to Chlorine*

***Model # CS-300***



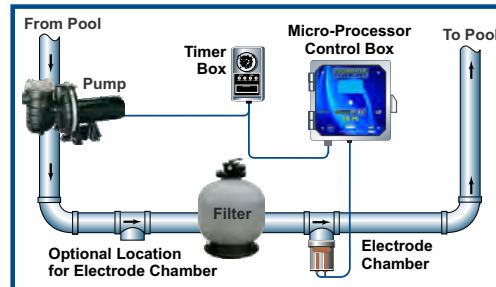
*Premium Model — handles up to 300,000 gallons*

**MineralPURE®**

**SPECIFICATION SHEET**

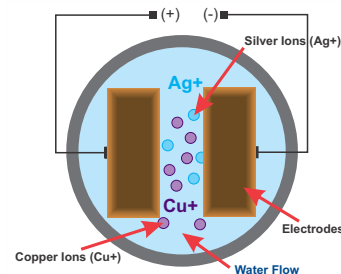
# How MineralPURE Works

The **MineralPURE** purification system consists of a state-of-the-art micro-processor control box and a scientifically designed set of **electrodes** composed of copper or copper/silver alloy that are set slightly apart from one another. Water is passed through a specially designed **flow cell chamber** that houses the electrodes. The control box works by generating a precise, low voltage, DC current (at milliamp levels) to the electrodes.



Basically, the current causes some of the outermost atoms of the electrodes to lose an electron, thus becoming positive ions. While the water is running through the chamber, many of these ions are swept away before they can reach the other side of the electrodes. As a result, the mineral ions are dispersed into the body of water that is being purified.

The greatest benefit of mineral ionization is that the ions remain in the water providing a residual protection. They provide **long-term, nontoxic purification** and prevent against recontamination. Unlike most other types of sanitizers, the mineral ions remain in the water until they flocculate, or form masses with algae and bacteria and then become large enough to be removed by the filtering equipment.



When the "used" mineral ions are removed, the microprocessor control box is always producing new mineral ions to continuously sanitize the water.



## CS-300 IONIZER SPECIFICATION SHEET

**POOL SIZE:** up to 300,000 U.S. gallons.

**INPUT VOLTAGE:** 90 to 264VAC, at 47 to 63 HZ, auto switching

**INPUT CURRENT and WATTAGE:** With electrode output set to 1000mA (max)

1.3A at 120VAC (156 Watts), 1A at 240VAC (240 Watts)

**OUTPUT VOLTAGE:** 2.5VDC to 20VDC, Auto Ranging, Dynamically Adjusted

**OUTPUT CURRENT:** Adjustable in 5mA increments

0 to 1000mA DC in analog mode (each output)

0 to 1000mA DC average in pulse width modulation mode (each output)

**CIRCUIT PROTECTION:** internal input fuse, both on high side and low side, input line spike/surge immunity to IEC 1000-4-5, level 3

**FUSES:** F1 - 2A, 250VAC, 5x20mm, Slow Blow / F2 - 4A, 250VAC, 5x20mm, Slow Blow

**IONIZATION METHOD:** electrolysis of copper or copper/silver alloy electrodes by a microprocessor control circuit

**ELECTRODE:** Four sets of electrodes, comprised of copper (CLE-05), copper/silver alloy electrodes are available - 7" long 90/10 copper/silver alloy electrodes (CLE-20), 6" long 80/20 copper/silver alloy electrodes (CLE-14), contact **Clearwater Enviro Tech** for details.

**ELECTRODE CHAMBER:** Customers choice between 3" or 4" tees or crosses

**ENCLOSURE:** weather resistant NEMA 4X (IP65) rated, UL 94 Flame Rating, UL UV rated, high impact corrosion resistant thermoplastic with hinged polycarbonate cover

**ENCLOSURE DIMENSIONS:** 16" x 14" x 7"

**OPERATING TEMPERATURE RANGE:** 32 - 110 degrees F

**WARRANTY:** 3 years, parts and labor - excluding electrodes

**SHIPPING WEIGHT:** 67 lbs.

**CARTON DIMENSIONS:** 24" x 24" x 24"

### HEAD LOSS:

When using:

CLF-49 - 3" Sch. 80 Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-51 - 3" Sch. 80 Cross Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-48 - 4" Sch. 80 Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-52 - 4" Sch. 80 Cross Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

**HYDROSTATIC PRESSURE:** Maximum Recommended Pressure: 50PSI

**USING THE CLE-05 ELECTRODE:** This Ionizer with the output set to 50% (500mA) produces 1.432 g of copper per hour. When set to 100% (1000mA) produces 2.864 g of copper per hour.



### ION PRODUCTION WITH THE FOLLOWING WATER CONDITIONS:

Water Temperature: 72.7 °F

Total Chlorine: None

pH: 7.45

TDS: 347 mg/L

Hardness: 215 mg/L

Total Alkalinity: 85 mg/L

# CLEARWATER™

P O O L S Y S T E M S

*The Healthy Alternative to Chlorine*

***Model # CS-450***



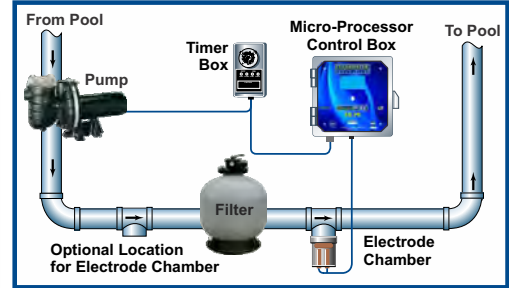
*Premium Model — handles up to 450,000 gallons*

**MineralPURE®**

**SPECIFICATION SHEET**

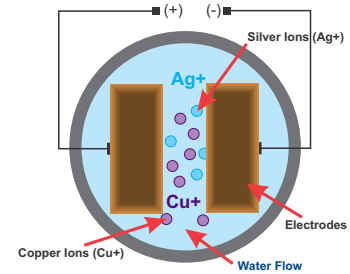
# How MineralPURE Works

The MineralPURE purification system consists of a state-of-the-art micro-processor control box and a scientifically designed set of **electrodes** composed of copper or copper/silver alloy that are set slightly apart from one another. Water is passed through a specially designed **flow cell chamber** that houses the electrodes. The control box works by generating a precise, low voltage, DC current (at milliamp levels) to the electrodes.



Basically, the current causes some of the outermost atoms of the electrodes to lose an electron, thus becoming positive ions. While the water is running through the chamber, many of these ions are swept away before they can reach the other side of the electrodes. As a result, the mineral ions are dispersed into the body of water that is being purified.

The greatest benefit of mineral ionization is that the ions remain in the water providing a residual protection. They provide **long-term, nontoxic purification** and prevent against recontamination. Unlike most other types of sanitizers, the mineral ions remain in the water until they flocculate, or form masses with algae and bacteria and then become large enough to be removed by the filtering equipment.



When the "used" mineral ions are removed, the microprocessor control box is always producing new mineral ions to continuously sanitize the water.



## CS-450 IONIZER SPECIFICATION SHEET

**POOL SIZE:** up to 450,000 U.S. gallons.

**INPUT VOLTAGE:** 90 to 264VAC, at 47 to 63 HZ, auto switching

**INPUT CURRENT and WATTAGE:** With electrode output set to 1000mA (max)  
1.6A at 120VAC (192 Watts), 1.4A at 240VAC (336 Watts)

**OUTPUT VOLTAGE:** 2.5VDC to 20VDC, Auto Ranging, Dynamically Adjusted

**OUTPUT CURRENT:** Adjustable in 5mA increments  
0 to 1000mA DC in analog mode (each output)

0 to 1000mA DC average in pulse width modulation mode (each output)

**CIRCUIT PROTECTION:** internal input fuse, both on high side and low side, input line spike/surge immunity to IEC 1000-4-5, level 3

**FUSES:** F1 - 2A, 250VAC, 5x20mm, Slow Blow / F2 - 4A, 250VAC, 5x20mm, Slow Blow

**IONIZATION METHOD:** electrolysis of copper or copper/silver alloy electrodes by a microprocessor control circuit

**ELECTRODE:** Six sets of electrodes, comprised of copper (CLE-05), copper/silver alloy electrodes are available - 7" long 90/10 copper/silver alloy electrodes (CLE-20), 6" long 80/20 copper/silver alloy electrodes (CLE-14), contact **Clearwater Enviro Tech** for details.

**ELECTRODE CHAMBER:** Customers choice between 3" or 4" tees or crosses

**ENCLOSURE:** weather resistant NEMA 4X (IP65) rated, UL 94 Flame Rating, UL UV rated, high impact corrosion resistant thermoplastic with hinged polycarbonate cover

**ENCLOSURE DIMENSIONS:** 16" x 14" x 7"

**OPERATING TEMPERATURE RANGE:** 32 - 110 degrees F

**WARRANTY:** 3 years, parts and labor - excluding electrodes

**SHIPPING WEIGHT:** 76 lbs.

**CARTON DIMENSIONS:** 24" x 24" x 24"

### HEAD LOSS:

When using:

CLF-49 - 3" Sch. 80 Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-51 - 3" Sch. 80 Cross Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-48 - 4" Sch. 80 Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-52 - 4" Sch. 80 Cross Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

**HYDROSTATIC PRESSURE:** Maximum Recommended Pressure: 50PSI

**USING THE CLE-05 ELECTRODE:** This Ionizer with the output set to 50% (500mA) produces 2.148 g of copper per hour. When set to 100% (1000mA) produces 4.296 g of copper per hour.



### ION PRODUCTION WITH THE FOLLOWING WATER CONDITIONS:

Water Temperature: 72.7 °F

Total Chlorine: None

pH: 7.45

TDS: 347 mg/L

Hardness: 215 mg/L

Total Alkalinity: 85 mg/L

# CLEARWATER™

P O O L S Y S T E M S

*The Healthy Alternative to Chlorine*

***Model # CS-600***



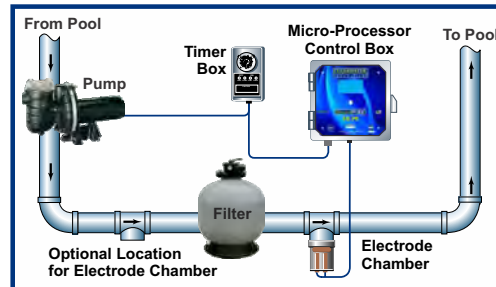
*Premium Model — handles up to 600,000 gallons*

**MineralPURE®**

**SPECIFICATION SHEET**

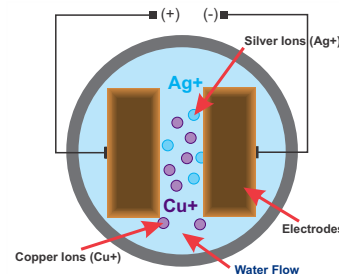
# How MineralPURE Works

The MineralPURE purification system consists of a state-of-the-art micro-processor control box and a scientifically designed set of **electrodes** composed of copper or copper/silver alloy that are set slightly apart from one another. Water is passed through a specially designed **flow cell chamber** that houses the electrodes. The control box works by generating a precise, low voltage, DC current (at milliamp levels) to the electrodes.



Basically, the current causes some of the outermost atoms of the electrodes to lose an electron, thus becoming positive ions. While the water is running through the chamber, many of these ions are swept away before they can reach the other side of the electrodes. As a result, the mineral ions are dispersed into the body of water that is being purified.

The greatest benefit of mineral ionization is that the ions remain in the water providing a residual protection. They provide **long-term, nontoxic purification** and prevent against recontamination. Unlike most other types of sanitizers, the mineral ions remain in the water until they flocculate, or form masses with algae and bacteria and then become large enough to be removed by the filtering equipment.



When the "used" mineral ions are removed, the microprocessor control box is always producing new mineral ions to continuously sanitize the water.



## CS-600 IONIZER SPECIFICATION SHEET

**POOL SIZE:** up to 600,000 U.S. gallons.

**INPUT VOLTAGE:** 90 to 264VAC, at 47 to 63 HZ, auto switching

**INPUT CURRENT and WATTAGE:** With electrode output set to 1000mA (max)

2.2A at 120VAC (264 Watts), 1.8A at 240VAC (432 Watts)

**OUTPUT VOLTAGE:** 2.5VDC to 20VDC, Auto Ranging, Dynamically Adjusted

**OUTPUT CURRENT:** Adjustable in 5mA increments

0 to 1000mA DC in analog mode (each output)

0 to 1000mA DC average in pulse width modulation mode (each output)

**CIRCUIT PROTECTION:** internal input fuse, both on high side and low side, input line spike/surge immunity to IEC 1000-4-5, level 3

**FUSES:** F1 - 2A, 250VAC, 5x20mm, Slow Blow / F2 - 4A, 250VAC, 5x20mm, Slow Blow

**IONIZATION METHOD:** electrolysis of copper or copper/silver alloy electrodes by a microprocessor control circuit

**ELECTRODE:** Eight sets of electrodes, comprised of copper (CLE-05), copper/silver alloy electrodes are available - 7" long 90/10 copper/silver alloy electrodes (CLE-20), 6" long 80/20 copper/silver alloy electrodes (CLE-14), contact **Clearwater Enviro Tech** for details.

**ELECTRODE CHAMBER:** Customers choice between 3" or 4" tees or crosses

**ENCLOSURE:** weather resistant NEMA 4X (IP65) rated, UL 94 Flame Rating, UL UV rated, high impact corrosion resistant thermoplastic with hinged polycarbonate cover

**ENCLOSURE DIMENSIONS:** 16" x 14" x 7"

**OPERATING TEMPERATURE RANGE:** 32 - 110 degrees F

**WARRANTY:** 3 years, parts and labor - excluding electrodes

**SHIPPING WEIGHT:** Box 1 - 35 lbs and box 2 - 68 lbs. Total 103 lbs

**CARTON DIMENSIONS:** Box 1 - 26" x 24" x 14" and box 2 - 18" x 18" x 18"

### HEAD LOSS:

When using:

CLF-49 - 3" Sch. 80 Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-51 - 3" Sch. 80 Cross Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-48 - 4" Sch. 80 Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

CLF-52 - 4" Sch. 80 Cross Tee - Flow Rate of 25 GPM Total Head Loss (psi) is < .20 PSI

**HYDROSTATIC PRESSURE:** Maximum Recommended Pressure: 50PSI

**USING THE CLE-05 ELECTRODE:** This ionizer with the output set to 50% (500mA) produces 2.864 g of copper per hour. When set to 100% (1000mA) produces 5.728 g of copper per hour.



### ION PRODUCTION WITH THE FOLLOWING WATER CONDITIONS:

Water Temperature: 72.7 °F

Total Chlorine: None

pH: 7.45

TDS: 347 mg/L

Hardness: 215 mg/L

Total Alkalinity: 85 mg/L

# K. OPENING A POOL

When warmer weather finally arrives, thoughts will return once again to outdoor activities and the pool. Before you take that first dip in the pool for the season, maximize your swimming pleasure by opening your pool properly. By following these opening steps, you can quickly get your pool ready for another season.

In general, opening a pool with a **Clearwater Ionizer** system with a copper and silver residual will be much easier and less costly than opening a pool which was closed the previous fall by adding some chlorine and algaecides.

Look under the cover as the weather becomes warmer. As the water begins to cloud up, and before it turns green, add any necessary fresh water to the pool for proper pump operation, and start the pump. The copper level may drop quickly at this time, since the cloudy water being filtered contains dead algae with copper attached. If the water is not filtered in time, the copper will be completely used up, and algae will begin to grow. As weather and time permits, continue with the following opening operating procedures.

First, clean your pool thoroughly. Make sure you brush all the crevices and vacuum the pool. If you can't see the bottom, add one gallon of household bleach per five thousand gallons. Even if you can see the bottom, you may still need to add some oxidizer or bleach.

Oxidize the water to burn up any organic material. If there is much organic matter in the water, you may need to double or triple the amount of oxidizer listed below.

1. Potassium Monopersulfate - 2 lb per 10,000 gallons.
2. Liquid chlorine - 1 quart per 10,000 gallons or 2 quarts of household bleach per 10,000.
3. If granular chlorine (such as HTH) is used, first dissolve it in water and pour it through the skimmer. **DO NOT ADD GRANULAR CHLORINE DIRECTLY TO THE POOL.** It may cause a black stain if it hits the bottom undissolved. Add 1/3 lbs. per 10,000 gallons.

Obtain new reagents for your test kits to assure accuracy for the coming season. New pH and copper reagents are particularly important.

Start with a good clean filter. If you have not changed the sand in your filter in the last two years, now would be a good time to do so. If the filter was not cleaned when the pool was shut down, give it a thorough cleaning now.

Bring the water up to the proper level and balance the water chemistry.

## RANGES

Copper	0.20 - 0.30 ppm
pH	7.2 -7.6
Total Alkalinity	80 - 100 ppm
Calcium Hardness	150 - 300 ppm
TDS	300 - 1500 ppm



# L. CLOSING A POOL

As the weather gets cooler, much less maintenance is required to prevent damage to your pool. The pH will not tend to change as much in the winter as it does in the summer. If you don't drain your pipes, filter and pump, it is advisable to run your pump at least one hour a week. If you can run your pump, check the pH level and adjust every two weeks; in very cold weather once a month is adequate. Operating the filter even one hour a week will help to minimize plaster staining and discoloration.

Keep pH between 7.2 and 7.6 total alkalinity levels should be between 50 and 100 ppm maintain a copper reading of 0.15 to 0.20 ppm.

Be sure to keep leaves out of the pool because they can cause staining. And, of course, putting a cover on your pool will make it easier to keep clean and is highly recommended. A few minutes of care to the pool during the winter months will lengthen the life of the pool and make spring cleanup much easier.

If you are running your pump during the winter months, be sure to turn the control on your system to the ZERO or LOW setting. You will not need to add much, if any, copper and silver to the pool during the cool weather.

If you are located in an area that freezes, it is very important that certain steps be taken to prevent damage to your pool. The pipes, filter, and pump must be drained.

Depending upon the type of pump you have, and the severity of the winter, you may want to disconnect your pump and store it. If you do so, follow the manufacturer's directions for lubricating and storing.

You also may need to drain the pool water to below the jets to allow draining of the pipes to prevent freezing. Your **Clearwater Ionization** system does not need any special attention.

Copper and silver usually keep your pool sparkling clear all winter. However, if leaves and other debris have fallen into the pool and algae starts to grow, it may be necessary to add a small amount of chlorine.

# M. COPPER, IRON & OTHER METALS ALREADY IN THE WATER

Sometimes a swimming pool will already have a copper residual. This residual may be from copper algaecides, copper plumbing and heaters, or may be from the city drinking water. Ideally, this residual should be lowered to less than 0.2 ppm and preferably less than 0.1 ppm, before the **Clearwater Ionization** system is turned on, otherwise the copper/silver balance will not be correct. This balance is necessary to ensure that sufficient silver is present in the water to kill bacteria. Since no silver will initially be present, a small amount of silver or chlorine is required to help kill the bacteria while the copper level is allowed to drop to the proper range.

Obviously, it is important to find the source of this copper and stop or slow its addition if possible. The most common source of copper is from copper algaecides that have been added previously.

Another source is from stagnant water in the copper plumbing leading out to the spigot by the pool. Check the copper level of the fill water and if copper is initially present, always allow it to run for 60 seconds before filling the pool.

Copper can also be etched from the heater by an improper water balance or the addition of acidic and corrosive chemicals to the skimmer. Even if the pH is okay now, it may not have been okay last week or last month.

The best way to remove this copper or excess copper added by an improperly monitored **Clearwater Ionization** system is to drain part of the water.

If the customer does not want to drain part of the water, there are some other methods to kill the bacteria while allowing copper to decrease over a period of a few weeks. (Remember, either silver or chlorine must be in the pool to kill the bacteria.)

If the copper level is at 0.35 ppm or below, one option is to turn on the **Clearwater Ionization** system to increase the copper level to 0.15 ppm above the current copper level. This will add enough silver to kill the bacteria. Then turn the control knob to "OFF". Do not allow the copper level to increase above 0.50 ppm.

Monitor the copper level, but do not turn the control knob to a higher setting until the copper level drops to 0.25 ppm. Be sure to continue adding an oxidizer each week.

Another method of dealing with a high copper level is based on test done by University of Arizona and other labs. They have shown that chlorine residuals of 0.10 to 0.20 ppm, when combined with copper will actually kill bacteria faster than one ppm of chlorine by itself. Therefore, a trace of chlorine (0.10 to 0.20 ppm) which is barely detectable with a test kit or by swimmers, may be used until the copper level drops to the proper range.

The best method to produce this trace of chlorine is to place a chlorine tablet or piece of a tablet in the skimmer. This is almost chlorine free swimming since the chlorine level will be undetectable. Follow this practice until the copper level is low enough (0.25 ppm) to allow the system to be turned on. Note: you will not need to add any oxidizer while there is a trace of chlorine in the water.

Iron should not present any problems unless it is causing staining or colored water. Normally, iron in the water is not tested unless it is known or suspected of being in the water. Iron can cause green or brown water and pool staining. If you have problems with iron, raise the pH to 8.5 then super chlorinate the pool. The next day vacuum the pool and add 2 pounds of Pool Stain Treat per 10,000 gallons. Adjust the pH the following day.

This process will cause the iron to precipitate (fall out of solution and form particles). Be sure to backwash or clean the filter after it has trapped the iron particles. Otherwise, the particles may start to dissolve back into solution.

Never add any chemicals that claim to “prevent staining”, “remove any metals” or “remove staining,” other than those expressly recommended by Clearwater Enviro Technologies. They will lock up the copper and algae may start to grow even though the test kit will still indicate that there is plenty of copper in the water.

Some brands that we have tested that caused problems are Sequasol, Cop-Out and Metal Magnet (not to be confused with Metal Magic).

Many times, these chemicals are routinely added when the pool is opened in the spring or closed in the fall. The customer may not be sure what was added to his pool.

If the pool has problems with algae while the copper level is in the correct range, it could be caused by one of these chemicals locking the copper up. Locked up copper is like locked up chlorine. It is not very effective. Locked up copper will still show up on the copper test kit.

The sequestering agents that lock up the copper will usually dissipate within two to three months. To speed up their breakdown and to temporarily release the copper, super chlorinate the pool by raising the chlorine level to over 10 ppm. Remember; do not add granular chlorine directly to a pool. Dissolve the chlorine in water and pour it into the skimmer.

Explain to the customer that this treatment may have to be repeated another time or two before all of the chemicals locking up the copper have been broken down. Doubling the normal weekly oxidizing treatment will release some copper and may solve the problem.

**Clearwater Enviro Technologies** can test for free available copper and tied up copper.

# N. IF THE COPPER LEVEL WON'T INCREASE

The actual time it takes to raise the copper level will vary from pool to pool and from unit to unit. A pool that takes up to a week to build up the proper amount of copper ions should not be a concern, but if there is no noticeable increase within three or four days, take the following steps to identify the problem. **Check -pages 52-54 for more info.**

**Note:** Even if you find something wrong from using this checklist, go ahead and check for all possible causes - the problem you are experiencing may actually involve two or more problems!

## PROPER SIZING OF UNIT

Make sure the system you have installed is large enough for the application. See Section II, chapter A "Sizing the System" for information.

## HIGH ALGAE GROWTH

One of the most common problems with new installations is allowing the chlorine level to drop before the copper level is high enough to take over. Under some conditions it is possible that algae may be able to grow rapidly at low copper levels, creating a copper demand that the system cannot meet. Use chlorine to kill the algae and always maintain a chlorine residual until the copper level is in the recommended range (.20-.40).

## CORRECT INPUT VOLTAGE

If the system is not producing near its maximum ion current, first check for an incorrect 115/230 VAC installation. Some of the **Clearwater** units will produce 50% of its full power if the unit was installed to a power source of 115 VAC and the unit is set to 230 VAC. Always test voltage at power source. *Don't take anybody's word for it.*

**Clearwater Pool Ionizers** can be configured for single-phase voltages of either 110-120 VAC or 210-220 VAC. All units are factory set at 220 VAC for your protection. Simple instructions are included in the installation manual to change to 110 V AC. Three phase voltages of 208 and 277 V AC are not acceptable. In most three phase pool applications, the ionizer may simply be plugged into a 110 V AC outlet. An optional pressure switch may be necessary.

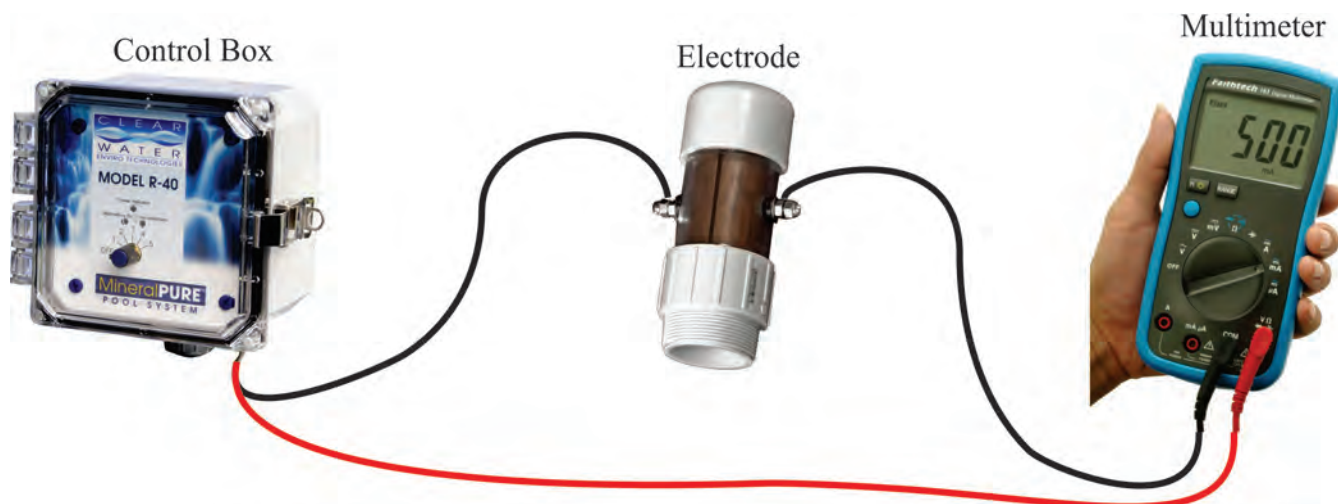
## SCALED ELECTRODES/ METER TESTING OF UNITS

One of the most common reasons for not obtaining the proper copper-ion level is from scaled electrodes. A calcium buildup between and around the electrodes may insulate the electrodes and reduce the amount of copper and silver-ions going to the water.

The old RS-50 (RC and CS units) have a check electrode light that will come on when you are unable to reach desired milliamp power on units. Visually check the electrodes for a greenish-blue buildup. See chapter “V” in this section “Cleaning and Replacing the Electrodes”. The unit will show the actual milliamp readout on the display screen.

The SPA-1R, SPA-2R, R-20, R-40 and old R-150 units do not have a digital readout. To obtain an actual digital readout being passed between the electrodes while in the water, you will need an amp meter. We recommend the Fluke 73 III Multimeter. Many people have problems setting the multimeter to the proper settings or do not know how to test the unit properly. **YOU MUST DO THE TESTING WITH THE ELECTRODES IN THE WATER FOR TRUE RESULTS. YOU WILL GET INCORRECT READINGS UNLESS THE FOLLOWING PROCEDURES ARE FOLLOWED:**

To obtain the actual current that is being passed between the electrodes while in the water, disconnect one of the wires coming out of the unit that was connected to the electrodes. The meter should have two connection wires coming out of it. Connect the wire coming from the ionizer (that was connected to the electrode) to one of the connection wires from the meter. Leave one set of the electrode wires connected to the ionizer. Then connect one of the meter wires to the other to the other electrode terminal. See drawing below.



Record the reading on the meter. It should be anywhere from zero to 500 or so (R-40 limit), or 250 (R-20 limit) and about 43 on spa units.

If the reading is indeed low and the unit is set on full blast, it may be time to clean the electrodes.

## **WORN ELECTRODES**

Over a period of time, the electrodes will wear down, and will get proportionately smaller in size as natural plating occurs. The further apart the electrodes get the less maximum output you will obtain. This is normal and should not be a concern *until you are unable to obtain the proper copper ion level*. The milliamp level will decrease, but there is no reason to replace the electrodes until you are unable to keep the copper-ion level in the proper range. See section “V” in this booklet for more information.

## **LOW TDS**

If the system has just been installed on a new pool or spa or the water has been just changed, there is a chance the TDS level is too low in order for the units to have enough conductivity. See TDS section of this book for more information

## **PROPER ELECTRODE INSTALLATION**

Make sure the electrode chamber is installed between the pump and filter, or after the filter. Do not install on the backwash line, solar heater line, or spa blower line. This does happen on occasion.

## **POOL CHEMISTRY**

It is most important that pool chemistry is balanced. A pH over 7.6 will cause problems with the copper falling out of solution. See various water chemistry chapters in this book.

## **IMPROPER TEST KIT READINGS**

Sometimes homeowners have a difficult time reading the copper-ion level with their test kit. Make sure they are properly trained on how to use the test kit. An old test kit or one left out in the sun will go bad and give false readings. See copper test kit section for more details in this book. Replace with new reagents.

## **METAL OUT REMOVERS**

The use of some brands of pool stain treatments or preventatives and chemicals that claim to take metals out of the water can cause some problems. Even though the ionizer is producing plenty of ions, they are getting sequestered out of the water. Some products that do cause problems are Sequasol, Alum, Cop-out, and Metal Magnet. There are many other names out there, but with the private labeling of products it's impossible to keep track of them all. See sequestering agent section for more details.

## **STEEL PLUMBING**

If the pool plumbing is composed primarily of steel (very common in many countries) there is a chance that this steel pipe can attract the charged copper and silver ions. Locate the electrode chamber as close to the outlet as possible so that the ions travel through less metal pipe. You may want to replace some of the pipe with PVC and upgrade the system to a larger one. See section of “Proper Sizing of a System”.

## **HIGH WATER TEMPERATURE**

A high water temperature allows for algae to grow at a rapid pace. This will, in turn, “gobble” up a lot of copper-ions. If the unit is in a warm water area, always oversize the unit.

## HIGH LEVELS OF PHOSPHATES, NITRATES, NITRITES, AMMONIA, SULFATE

A high level of phosphates, nitrates, nitrites, ammonia or sulfate will affect the copper-ion level and the growth of algae. See proper sections in this booklet.

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## HEADQUARTERS WATER TESTING

**Clearwater** offers *free* water testing to all its customers and dealers. We have a complete water-testing laboratory on site, and can test the water within 24 hours of receiving it. If you are unable to obtain the proper copper-ion level, or the water is always cloudy, please call us with your problem. We are always ready to help you. We will advise you to send us a water sample if necessary. We can also test for phosphates, nitrates, nitrites, ammonia, sulfates and much more.

When sending a water sample, *never* send glass in the mail or UPS. Always call the office first with your problem- and we will advise if a water sample is needed. When sending a water sample enclose at least 16 ounces of water in a plastic container along with a note to remind us with your problem. This is important because there are dozens and dozens of tests that can be done on your water, and we would like to pinpoint the problem before the testing begins.

Always include your name, phone number, best time to call and description of the problem with the water sample.

On the following page is a copy of the “Water Test Results” that we fill out. We can also fax you a copy of this if desired.



# WATER TEST REQUEST FORM

All water samples should be sent in a plastic container of at least 12 ounces.

Company Name:	
Customer Name:	
Address:	
City:	State:
Phone Number:	Mobile Phone Number:
E-mail:	

CET Rep.	Size of Pool	Unit Installed
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Date of water test:
Water sample labeled:

Description of problem –
Has anything been added to the water in the pool or spa? (Algaecides, stain removers, etc.) -
When did the problem first occur? -





## ***WATER TEST RESULTS***

Date: \_\_\_\_\_

Dealer name: \_\_\_\_\_ Contact info: \_\_\_\_\_

Customer name: \_\_\_\_\_ Contact info: \_\_\_\_\_

New installation     Troubleshooting     Other \_\_\_\_\_

Note: \_\_\_\_\_  
\_\_\_\_\_

### **RESULTS OF TEST**

Free chlorine	_____ ppm	Cyanuric Acid	_____ ppm
Total chlorine	_____ ppm	TDS	_____ ppm
pH	_____	Copper	_____ ppm
Acid/base demand	_____ drops	Sequestering agent	_____ ppm
Total Alkalinity	_____ ppm	Phosphates	_____ ppm
Calcium Hardness	_____ ppm	Other	_____ ppm

Final Analysis:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Lab test conducted by: \_\_\_\_\_

Date: \_\_\_\_\_ Other: \_\_\_\_\_

# O. CLOUDY WATER

Cloudy water is always caused by very small particles in the water. The water will not be clear until the particles are removed. There are three ways to remove these particles. For quick results do all three at once.

1. **OXIDIZE (BURN UP) THE ORGANIC MATTER** - Add two pounds of oxidizer (potassium monopersulfate) or one gallon of household bleach (such as Clorox) per 10,000 gallons. Pour the bleach into the skimmer after sundown. If the problem is really bad, you may need to double or triple the amount of oxidizer or bleach. Don't worry about swimming in chlorine. It will all be gone the next day after a few hours of sunshine.
2. **DISSOLVE THE INORGANIC SUSPENDED SOLIDS** - Do this by adding acid to lower the pH to 7.2
3. **FILTER OUT THE PARTICLES** - To filter out particles, two things are important: First, all of the water must pass through the filter. Second, the filter must catch these particles. Make sure the filter is cleaned or back washed. Temporarily increase filtration time to 24 hours per day. Make sure the bottom drain is open or the pool vacuum is working. If the pool does not have a bottom drain or a pool vacuum, put the vacuum hose in the skimmer and drop one end into the deep end of the pool.

If the water is still cloudy the next day, temporarily pull water only from the bottom drain. If the pump cavitates (air bubbles form in the strainer basket and the pump creates an unusual sound) open the skimmer valve slightly. To keep clear water it may be necessary to continue operating the pool with the skimmer valve only slightly open. If the water still is not clear, the problem is most likely related to the filter. Review the section of filtration.

One quick way to test the filtration system is to add two pounds of D.E. to the skimmer and watch the return jets. If you see a large cloud appear from the jets, you will know some of the water is bypassing the filter. It is normal to see a small cloud when D.E. is first added to a D.E. filter.

If you suspect a filter problem by this method, the valving may be defective, there may be a hole in the cartridge or D.E. fabric, or there may be a channel through the sand. There is no way to get clear water until this filter problem is fixed. Of course, if you don't see a "cloud" it probably means the filter system is okay.

Any time D.E. is added to a sand or cartridge filter be sure to monitor the pressure gauge and backwash or clean the filter when the pressure builds up to the recommended limit for that filter (usually eight PSI above the clean filter pressure).

# P. ALGAE

Algae contains an internal green pigment call chlorophyll. Algae may be found in every water supply that is exposed to sunlight and some that aren't. It is possible to develop a thriving algae population in a 24 hour period. Algae spores and cells are brought into the pool by wind, rain and makeup water. Note that the term algae is plural although many people incorrectly speak of algae in the singular sense. The correct singular term is alga.

## TYPES OF ALGAE

Clinging types of algae grow profusely in pores and crevices. Some algae develop in corners where water circulation is poor. Blue-green algae, sometimes called black algae grow in buds or pods. If unchecked, black algae can destroy marcite or plaster with its roots, much as trees and plants help break down soil and rocks.

Slippery green algae tend to grow along the pool sides and bottom. Algae reproduces more rapidly at moderate temperatures. Swimmer waste stimulates algae growth. Floating algae are visible to the naked eye at 30,000 cells per ounce of water. This means there can be a lot of algae in the pool even though you can't see it. There are many species of algae and each has its own resistance to algaecides.

Many algae are green, but some look like dirty brown to the naked eye. If conditions are unfavorable from growth, algae plants produce spores, dry up and float with the wind. If the spores drop into water and conditions are favorable, look out!

## ALGAE REMOVAL

If the copper level becomes low and there are algae in the pool, correct the problem quickly as follows:

1. Raise the copper level to a full 0.30 ppm. If you have a species of algae that is difficult to kill, temporarily increase the copper level to 0.40 ppm for two weeks.
2. Add two pounds of oxidizer (potassium monopersulfate) or one gallon household bleach per 10,000 gallons. This will release any locked up copper and help the copper to be more effective.
3. Brush the pool walls and steps where algae are visible. Run the pump 24 hours a day.

## BLACK ALGAE REMOVAL

If black algae gets started in a pool, take immediate steps to get rid of it. Rub the top layer off with a chlorine stick, and then apply an algaecide directly to the algae. Keep treating it every time algae starts to show up. Don't relent. Black algae has deep roots and will keep coming back until it is completely killed.

Another way to kill black algae is to use a stainless steel brush to knock off the buds. Lower the pH of the water to 7.2. Turn off the pump and wait 15 minutes for the water to stop moving. Slowly pour a gallon of household bleach in the area where the black algae are. If there are several spots, use several gallons. You can dissolve one cup of granular chlorine in a gallon of water to use instead of household bleach. Remember; do not pour the undissolved granular chlorine into the pool.

The next day start the pump, vacuum up the mess and brush again. Re-adjust the pH. Turn the control knob to high to raise the copper to 0.40 ppm. Leave the copper at 0.40 ppm for two weeks, then let the copper come back down to 0.20- 0.30 ppm .

Black algae only grow in gunite type pools. Sometimes a fungus behind vinyl liners looks like black algae. See Vinyl Liner Stains (Section T). Black algae will always break off in tiny pieces as it is rubbed or brushed.

## LOCKED UP COPPER

The use of some brands of pool stain treatments or preventatives and chemicals that claim to take the metals out of the water can reduce the effectiveness of copper, allowing algae to grow.

Some brands that we have tested that caused problems are: Sequasol, Cop-Out and *Metal Magnet* (not to be confused with *Metal Magic*). Many times, these chemicals are routinely added when the pool is opened in the spring or closed hi the fall. The customer may not be sure what was added to his pool.

If the pool has problems with algae while the copper level is in the correct range, it could be caused by one of these chemicals locking the copper up. Locked up copper is like locked up chlorine. It is not very effective. Locked up copper will still show up on the copper test kit.

The sequestering agents that lock up the copper will usually dissipate within two or three months. To speed up their breakdown and to temporarily release the copper, super chlorinate the pool by raising the chlorine level to over 10 ppm. Explain to the customer that this treatment may have to be repeated another time or two before all of the chemicals locking up the copper have been broken down. Doubling the normal weekly oxidizing treatment will also release some copper and may solve the problem.

## Q. GREEN TINTED WATER

On rare occasions the water may develop a clear green tint. The water may be clear with no algae, but has a green tint color to it.

This is usually caused by the pool chemistry being out of balance. Solve the problem by balancing the pool chemistry. Be sure to lower the pH if it is too high. To get rid of the green tint, add one gallon of household bleach for each 10,000 gallons of pool water. The green tint will be gone in minutes.

There is no cause for alarm if this happens. The green tint is caused by copper or iron changing molecular states.

In some case the pool water may be crystal clear and blue for many days or months and then suddenly turn to a clear green. This is normally caused by a change in oxidation state of the copper or iron in the water, and can easily be corrected by oxidizing the pool with chlorine. The water should revert to its original colorless state. If the water regains the green tint within a few days, there are other problems causing the tint.

## HIGH SULFATE LEVELS

A pool with a high sulfate level of over 80 ppm can cause green tinted water. This is rarely a problem as most pools contain no more than 20 ppm of sulfate.

If it is a problem, a filtering device called a scrubber will remove the sulfate from the water, so you can drain the water and refill it with fresh water. Before refilling it with fresh water, test the water for sulfates out of the tap first. Some areas have a high sulfate level coming out of the tap.

## R. BLACK LADDERS

If a black substance ever forms around anything metal in the pool (ladders, light holder), the cause is a combination of our ionization taking place along with the “ungrounded” metal.

To correct this problem, remove the metal from the pool and clean off with muriatic acid. It will come right off. Replace the metal in the pool. To stop this from happening again, check the pool’s pump and motor. Chances are the motor was recently replaced and not grounded.

If the ladder is turning black and the motor is grounded, chances are this is a very old pool and the ladder is not grounded. To correct this problem, lift the ladder out of the ground and wrap some heavy duty tape around the area that goes into the ground. What’s happening is the ground water or dampness is getting to the ladder in the ground. Older pools did not ground or secure the ladders back then. This should correct the problem.

Also check the copper level- it may be too high -and test the water chemistry.

This is very rarely a problem, but it can happen.

# S. GUNITE STAINS

Gunite pools, even when properly cared for, are not impervious to discoloration throughout their life.

## ORGANIC STAINS

Leaves, twigs, grass clippings, as well as the creatures commonly found dead in pools, will all eventually sink to the bottom, and deteriorate. As this decomposition occurs, many organic compounds are released which can cause a stain on the surface of the pool. These stains only occur after an extended decay period, as is commonly found over the winter months. Weekly cleaning of the pool bottom of accumulated debris both in the summer and the winter will reduce this type of staining. A pool cover is an excellent tool for keeping the Fall and Winter debris out of the pool.

Organic stains of this type are best removed with an oxidizer such as chlorine. Chlorine acts on the organic stains much as it acts on grass stained clothes. While gunite pools are much more tolerant to high chlorine levels, it is still better to add 2 ppm chlorine for 3 days, rather than to try and remove the stain in one day with 6 ppm chlorine. Of course a bad organic stain may not be easily removed with low levels of chlorine, and temporarily raising the chlorine level to 20 or even 30 ppm is permissible on gunite pools. Under no circumstances should granular chlorine be applied directly to the gunite surface if metals, including copper, are present in the water, as this can produce a new stain.

## INORGANIC STAINS

Stains which are caused by metals are classified as inorganic stains. Coins, bobby pins and metal yard debris such as paint can lids are the most common source of metal stains.

Chlorine does not remove metal stains well, just as it does not remove rust stains from clothing. Oxidizers which have an affinity for metals are required for this type of stain removal. Muriatic acid, potassium monopersulfate, and the ingredients in Pool Stain Treat and Metal Magic all have this affinity for metals.

Muriatic acid while being the quickest to remove these stains, is also the most harmful to gunite pools and should not be poured directly on the gunite surface unless diluted to at least 50%, as is done in acid washing.

Potassium monopersulfate and Pool Stain Treat may be added directly to the stain, but excessive applications are not recommended. The Pool Stain Treat Spotting Bag can be placed directly on the stain, or potassium monopersulfate may be poured into a sock and placed on the stain. If the pool has more stains than you have socks, the entire pool may be treated by lowering the pH to 6.8 with acid, and then adding 2 pounds of potassium monopersulfate per 10,000 gallons. You may triple the dose of oxidizer or repeat as necessary.

Remember that oxidizers and acids will lower the pH, and the pump should not be run while the pH is below 7.0, since a heater or metal plumbing could add additional copper or iron to the water.

## **COPPER AND IRON STAINS**

Normally metals do not cause stains on gunite surfaces unless the water chemistry is out of balance or the level of metals in the water is excessively high. The stains caused by metals may range in color from gray to green to blue to rust, and will usually produce a mottled or streaked appearance.

Because of the nature of this staining which is caused by scaling, certain characteristics of the gunite surface may make it more or less prone to this discoloration. It is not uncommon to find a pool completely unstained with the exception of a few areas which were obviously final trowel marks made by the pool builder, possibly as a touch up. On the other hand, the stain may cover the entire pool, except for areas which were recently patched. In general, rough areas are more prone to scale formation' and staining than smooth areas.

## **METAL STAIN REMOVAL**

Staining caused by metals is not an overnight process. It is important therefore to understand that unless the most drastic of stain removal methods is employed, the stain will not disappear quickly.

The best method of removing a stain will depend on the extent of the stain, how long the stain has been present, and the amount of time available to remove the stain.

## **SIMPLE STAINS**

Most light staining can be easily reversed by simply correcting the water chemistry imbalance which has caused the stain and by adding 2 pounds of Pool Stain Treat per 10,000 gallons.



## MORE NOTICEABLE STAINS

Staining which is easily visible from the pool deck, and has not been on the pool long, may be treated with the following procedure:

1. Turn off the pump and allow the water to stop moving.
2. Dilute two quarts of acid per 10,000 gallons in a bucket of water and pour around the perimeter of the pool as close to the wall as possible, without splashing on the wall.
3. Dissolve 2 pounds of Pool Stain Treat per 10,000 gallons in a bucket of water per the label directions and pour around the perimeter of the pool as was done with the acid.
4. Allow the water to remain still for at least one hour before starting the pump.  
Repeat this application the next day, and wait one week before making a final judgment on its effectiveness.

## VERY NOTICEABLE

Stains that cover a pool and are very noticeable should be acid washed. A licensed pool professional should do this job. In short, this requires the draining of the pool, and the brushing or spraying of the pool surface with diluted muriatic acid. This is not a fun task and will usually take a full 8 hour day by one man. Special precautions are required for an acid washing - always consult a reputable pool dealer or pool serviceman.

# T. VINYL LINER STAINS

Vinyl liners, which are properly cared for, remain fairly impervious to discoloration throughout their life. However, some discoloration or fading with age is normal, and liners which are not properly cared for may exhibit both reversible and non-reversible color changes.

## DAMAGE BY SUNLIGHT

The areas of the liner that are above the water line are constantly exposed to the ultraviolet rays of the sun. Like most plastics, long term exposure to sunlight will cause a slow hardening of the elastomers, a bleaching of the color, and eventual dry rotting of the liner.

Typically, a liner suffering from this condition will exhibit a dull and dirty appearance above the water line which is not improved by the use of cleaners. The areas of the liner that are stretched, usually at inside corners, will appear hard and less supple than that of the rest of the liner. Be careful when inspecting stretched corners, as it is possible to crack a liner which has hardened.

## ORGANIC STAINS

Leaves, twigs, grass clippings, as well as the creatures commonly found dead in pools will all eventually sink to the bottom and deteriorate. As this decomposition occurs, many organic compounds are released which can cause a stain on the surface of the liner. These stains only occur after an extended decay period as is commonly found over the winter months. Weekly cleaning of the pool bottom of accumulated debris both in the summer and the winter will reduce this type of staining. A pool cover is an excellent tool in keeping the fall and winter debris out of the pool.

Organic stains of this type are best removed with an oxidizer such as chlorine. Chlorine acts on the organic stains much as it acts on grass stained clothes. But just as too much chlorine can easily destroy the clothes, too much chlorine can also destroy the liner. When removing an organic stain in a vinyl liner pool, it is much better to treat the pool with 2 ppm chlorine for three days, than to try and remove the stain in one day with 6 ppm chlorine.

## INORGANIC STAINS

Stains which are caused by metals are classified as inorganic stains. Coins, bobby pins and metal yard debris such as paint can lids are the most common source of metal stains.

Chlorine does not remove metal stains well, just as it does not remove rust stains, from clothing. Oxidizers which have an affinity for metals are required for this type of stain removal. Muriatic acid potassium monopersulfate, and the ingredients in Pool Stain Treat and Metal Magic all have this affinity for metals.

Muriatic acid is the quickest to remove these stains, but it is also the most harmful to liners and should not be added directly to a small area of the pool, and should never be poured directly on the liner.

Potassium monopersulfate and Pool Stain Treat may be added directly to the liner, but excessive applications are not recommend. The Pool Stain Treat Spotting Bag can be placed directly on the liner, or potassium monopersulfate may be poured into a sock and placed on the liner. If the pool has more stains than you have socks, the entire pool may be treated lowering the pH to 6.8 with acid, and then adding 2 lbs. of potassium monopersulfate per 10,000 gallons. A triple dose of oxidizer may be used and repeated as necessary.

## COPPER AND IRON STAINS

Normally vinyl is impervious to stains caused by dissolved metals in the water. However, it is possible for the protective coating on the surface of the liner to become damaged or completely removed by excessive chlorine levels, or excessively low pH. Incorrect chemical addition may also cause a deterioration of the coating.

Once the coating is removed, the vinyl surface is free to obtain additional pigmentation in the form of dissolved metals. Some of the cheap plastics used in pool steps and skimmers may not have any form of protective coating.

In general, this type of metal staining occurs on non-colored areas of the plastic. For example, a standard blue pebble bottom with white background will only show staining in the white background, and it will not exhibit staining of the blue pebbles.

Generally this discoloration is a gray to gray green to brown color, and is easily removed by lowering the pH to 6.8 or by adding 2 lbs of potassium monopersulfate per 10,000 gallons. Proper maintenance of the pH, and total alkalinity will help prevent this stain from reoccurring. Applying potassium monopersulfate directly to the stain or discolored area will usually give immediate results.

## BLEACHED LINERS

Pools with white spots or white vertical streaks on the walls are caused by the repeated chemical addition at these areas of the pool. Normally these bleached areas at the edges of the pool are close to the chemical storage area. Pools which are completely bleached have a history of very high chlorine levels.

Any bleached area of the pool is very susceptible to staining of any kind.

## FUNGUS

The dark moist area under the vinyl liner is an excellent habitat for fungus growth. While most vinyl liner manufacturers now add biostatic chemicals to their liners to stop fungus attack, these chemicals are not completely effective, just like mildew resistant paint will not always eliminate mildew. Older liners may not have this protection.

Dark splotches or streaks which do not limit themselves to the white areas such as metal stains do, and appear in colors from pink to purple to brown and black, are likely to be caused by a fungus. Many times fungus stains are mistakenly diagnosed as black algae. It does look like and act like black algae since a strong dosage of chlorine will temporarily remove the stain, and it may have the same deep color when observed from the pool deck. Black algae; however, doesn't grow on vinyl liners since there is no place for the roots to establish themselves, as there is in a gunite pool. Pieces of black algae can always be broken or brushed from the pool wall, while the fungus stain is actually in the liner, and cannot be brushed off.

Differentiating other forms of stains from fungus staining is simple since chlorinating the pool for a few days with normal residual levels of chlorine, will lighten or remove the splotches, however, they will return when chlorination is discontinued, and will return in exactly the same pattern. Staining by any other means is usually random.

The fungus itself is actually not visible, as it grows and feeds on the back side of the liner. The waste products of the fungus permeate the liner and produce the visible splotchy color. The use of chlorine serves only to bleach this visible organic discoloration from the liner, and has no effect on the fungus.

It is for this reason than fungus problems, if present, will manifest after the **Clearwater Pool** system is installed and the regular chlorination is stopped. Usually the appearance of this problem is slow and may take several weeks to become noticeable.

The source of the fungus can be attributed to pool construction and water table. The sand or vermiculite used as well as all other materials in contact with the liner should be treated with a fungicide before the liner is installed. Dredged river sand should never be used to fill or level a pool bottom, as this sand has been shown to be a major cause of fungus introduction.

High water tables seem to also play a role in the spread of fungi, but proper preventative treatment by the installer will help prevent fungus growth.

Des

truction of the fungus can only be performed from the back side of the liner. If the fungus is located on the sides, the water may be drained, and chlorine bleach may be poured down the inside of the liner, followed by a fungicide. If the fungus cannot be reached by this method, the removal of the liner will be required. Injection of chlorine and fungicides with a hypodermic needle has been used when there are only one or two small spots. Success has also been achieved by sliding a thin tube under an above ground liner and pumping chlorine and fungicide to the affected area. Chlorination of the front side of the liner will remove the discoloration, after the fungus is killed.

If treating the liner is not practical, the splotchy appearance caused by the fungus may be controlled by the weekly addition of liquid bleach or oxidation directly over the area of the fungus. Slow destruction of the liner by chlorination is no longer a concern, since allowing the fungus to grow is doing the greatest amount of damage.

# U. BAQUACIL REMOVAL PROCEDURE

Because of the incompatibility of Baquacil with the other forms of purification, all Baquacil must be removed prior to operating the **Clearwater Ionizer**.

When the customer converted to baquacil, they knew that nothing could be in the water with it (chlorine, bromine) So they will understand that if you are converting them to the **Clearwater** system, the Baquacil will have to be removed. The problem is, it's not as easy as letting the chlorine or bromine evaporate.

After converting nearly 100 Baquacil customers over to the **Clearwater system**, we have found the quickest and most reliable method is to totally change the water. Special precautions should be followed when draining the entire pool - consult a professional pool service man before doing so.

Once the pool has been drained, the walls and bottom must be rinsed off. If it is a fiberglass or concrete pool, use chlorine to wash off the walls. This will remove every speck of baquacil that may be on the walls. If it is a vinyl liner pool, just rinse the walls with a water hose.

The next step is to clean the filter.

**Sand filter** - the sand must be completely changed.

**D.E. filter** - change the D.E., clean the grids, and remove all accumulations of D.E. and debris from the bottom of the filter.

**Cartridge filter** - Soak the cartridges in a mixture of one part chlorine and four parts water for a couple of hours.

It is best to clean the filters when the pool is draining.

After refilling the pool, check it with liquid chlorine or bleach and turn the filter on. If there is still some baquacil in the water, the water will turn blackish when the copper and silver -ions are in the water.

You should charge the customer an extra \$200 - \$300 for this job on top of the **Clearwater Ionizer** price. Don't throw this job in "for free" just because they bought the ionizer. There is a lot of work getting the Baquacil out of the pool, but the cost advantages to the customer are well worth it.

# V. CLEANING AND REPLACING THE ELECTRODES

The copper/silver electrodes will last anywhere from a few months to several years. Factors that contribute include pool size, water temperature, flow rate, bather load, filter condition and chemistry balance. For example, a pool in Maine that is 10,000 gallons may last several years, while a pool in Florida that is 50,000 gallons will last 6 months. There is no guarantee on how long the electrodes last.

When you are unable to reach the required milliamp level to maintain the required copper-ion level it is time to check the electrodes.

The first step is to clean the electrodes that have foreign matter on them. Use an old tooth brush or regular brush and clean the electrodes using a 50-50% solution of muriatic acid and water, or lemon juice concentrate. Do not allow the acid to contact the external electrical connections. It is not necessary for the electrodes to have a polished appearance - just remove the soft calcium scale. A blue-greenish coating around the electrodes is normal.

The electrodes should be checked every three or four months. With the exception of the SPA-2R units, all of the units include a see-through window for viewing. Sometimes the window will cloud up, and you will have to remove the electrodes from the chamber and visually inspect.

If the electrodes are worn out, a new set will need to be installed. Simply disconnect the wires going to the electrodes, unscrew the electrodes and replace with a new set. The RC-50 units can be done without tools and Teflon tape. All other electrodes will require Teflon tape. Always wrap several inches of Teflon tape around the threads of the electrodes cap every time you remove or replace the electrodes. This will prevent any leaking. Reconnect the electrodes wires (it doesn't matter which wire is connected to the terminals) and check the milliamp reading on the display window, or use a voltage meter to test the readout.

Only replace the electrodes when you are unable to reach the desired copper-ion level. Always contact **Clearwater** for replacement bars, or visit our special website at - [www.electrodewarehouse.com](http://www.electrodewarehouse.com)

Clearwater maintains a large inventory of several replacement electrodes of all types and sizes - not only for Clearwater's models, but for competitors too.

# W. WATER TREATMENT TABLES

Once all the tests for water balance have been completed, and the need for treatment determined, the following tables can be used to find the correct amount of treatment chemical to add. Turn to the appropriate table and using the column with the correct volume of water, determine the amount of treatment chemical to add.

By using combinations of various columns, you can determine the exact amount of treatment chemical needed. For example, for a 30,000 gallon pool, the column value for 20,000 plus 2 times the 5,000 gallon column value will give you an approximate amount of treatment chemical needed. Alternatively, the 20,000 gallon column plus 0.5 times the 20,000 gallon column value will give the same result.

Each chart is broken down in English and metric conversions.

**TABLE A** - Amount of chlorine compound to introduce 1 ppm chlorine.

**TABLE B** - 30 ppm shock table for algae removal.

**TABLE C** - To decrease free chlorine using sodium sulfite.

**TABLE D** - To increase pH using soda ash.

**TABLE E** - To decrease pH using muriatic acid.

**TABLE F** - To decrease pH using dry acid.

**TABLE G** - To increase alkalinity using baking soda.

**TABLE H** - To decrease alkalinity using dry acid.

**TABLE I** - To decrease alkalinity using muriatic acid.

**TABLE J** - To increase calcium hardness using calcium chloride.



# TABLE A

## Amount of Chlorine Compound to Introduce 1 ppm Chlorine

Volume of Water							
% Available Chlorine *	400 gallons	1000 gallons	5000 gallons	10,000 gallons	20,000 gallons	50,000 gallons	100,000 gallons
5%	1.02 fl oz	2.56 fl oz	12.8 fl oz	1.60 pts	1.60 qts	1.00 gal	2.00 gal
10%	0.51 fl oz	1.28 fl oz	6.40 fl oz	12.8 fl oz	1.60 pts	2.00 qts	1.00 gal
12%	0.43 fl oz	1.07 fl oz	5.33 fl oz	10.7 fl oz	1.33 pts	1.67 qts	3.33 qts
35%	0.15 oz	0.38 oz	1.91 oz	3.82 oz	7.63 oz	1.19 lbs	2.38 lbs
60%	0.09 oz	0.22 oz	1.11 oz	2.23 oz	4.45 oz	11.1 oz	1.39 lbs
65%	0.08 oz	0.21 oz	1.03 oz	2.05 oz	4.11 oz	10.3 oz	1.28 lbs
90%	0.06 oz	0.15 oz	0.74 oz	1.48 oz	2.97 oz	7.42 oz	14.8 oz
100%	0.05 oz	0.13 oz	0.67 oz	1.34 oz	2.67 oz	6.68 oz	13.4 oz

Volume of Water							
% Available Chlorine *	2000 L	4000 L	20,000 L	40,000 L	80,000 L	100,000 L	400,000 L
5%	40.0 mL	80.0 mL	400 mL	800 mL	1.60 L	2.00 L	8.00 L
10%	20.0 mL	40.0 mL	200 mL	400 mL	800 mL	1.00 L	4.00 L
12%	16.7 mL	33.33 mL	167 mL	333 mL	667 mL	833 mL	3.33 L
35%	5.71 g	11.4 g	57.1 g	114 g	229 g	286 g	1.14 kg
60%	3033 g	6.67 g	33.3 g	66.7 g	133 g	167 g	667 g
65%	3.08 g	6.15 g	30.8 g	61.5 g	123 g	154 g	615 g
90%	2.22 g	4.44 g	22.2 g	44.4 g	88.9 g	111 g	444 g
100%	2.00 g	4.00 g	20.0 g	40.0 g	80.0 g	100 g	400 g

# TABLE B

## 30 ppm Shock Table for Algae Removal

Volume of Water							
% Available Chlorine *	400 gallons	1000 gallons	5000 gallons	10,000 gallons	20,000 gallons	50,000 gallons	100,000 gallons
5%	1.92 pts	2.40 qts	3.00 gal	3.00 gal	6.00 gal	15.0 gal	30.0 gal
10%	15.4 fl oz	1.20 qts	1.50 gal	3.00 gal	6.00 gal	15.0 gal	30.0 gal
12%	12.8 fl oz	1.00 qts	1.25 gal	2.50 gal	5.00 gal	12.5 gal	25.0 gal
35%	4.58 oz	11.4 oz	3.58 lbs	7.15 lbs	14.3 lbs	35.8 lbs	71.5 lbs
60%	2.67 oz	6.68 oz	2.09 lbs	4.17 lbs	8.35 lbs	20.9 lbs	41.7 lbs
65%	2.47 oz	6.17 oz	1.93 lbs	3.85 lbs	7.70 lbs	19.3 lbs	38.5 lbs
90%	1.78 oz	4.45 oz	1.39 lbs	2.78 lbs	5.56 lbs	13.9 lbs	27.8 lbs
100%	1.60 oz	4.01 oz	1.25 lbs	2.50 lbs	5.01 lbs	12.5 lbs	25.0 lbs

Volume of Water							
% Available chlorine*	2000 L	4000 L	20,000 L	40,000 L	80,000 L	100,000 L	400,000 L
5%	1.20 L	2.40 L	12.0 L	24.0 L	48.0 L	60.0 L	240 L
10%	600 mL	1.20 L	6.00 L	12.0 L	24.0 L	30.0 L	120 L
12%	500 mL	1.00 L	5.00 L	10.0 L	20.0 L	25.0 L	100 L
35%	171 g	343 g	1.71 kg	3.43 kg	6.86 kg	8.57 kg	34.3 kg
60%	100 g	200 g	1.00 kg	2.00 kg	4.00 kg	5.00 kg	20.0 kg
65%	92.3 g	185 g	923 g	1.85 kg	3.69 kg	4.62 kg	1835 kg
90%	66.7 g	133 g	667 g	1.33 kg	2.67 kg	3.33 kg	13.3 kg
100%	60.0 g	120 g	600 g	1.20 kg	2.40 kg	3.00 kg	12.0 kg

# TABLE C

## To Decrease Free Chlorine Using Sodium Sulfite

Volume of Water							
Desired decrease in ppm	400 gallons	1000 gallons	5000 gallons	10,000 gallons	20,000 gallons	50,000 gallons	100,000 gallons
1 ppm	0.09 oz	0.24 oz	1.19 oz	2.37 oz	4.75 oz	11.9 oz	1.48 lbs
2 ppm	0.19 oz	0.47 oz	2.37 oz	4.75 oz	9.49 oz	1.48 oz	2.97 lbs
3 ppm	0.28 oz	0.71 oz	3.56 oz	7.12 oz	14.2 oz	2.23 oz	4.45 oz
4 ppm	0.38 oz	0.95 oz	4.75 oz	94.9 oz	1.19 lbs	2.97 lbs	5.93 lbs
5 ppm	0.47 oz	1.19 oz	5.93 oz	11.9 pz	1.48 lbs	3.71 lba	7.42 lbs
10 ppm	0.95 oz	2.37 oz	11.9 oz	1.48 lbs	2.97 lbs	7.42 lbs	14.8 lbs
15 ppm	1.42 oz	3.56 oz	1.11 lbs	2.23 lbs	4.45 lbs	11.1 lbs	22.6 lbs
20 ppm	1.90 oz	4.75 oz	1.48 lbs	2.97 lbs	5.93 lbs	14.8 lbs	29.7 lbs
30 ppm	2.85 oz	7.12 oz	2.23 lbs	4.45 lbs	8.90 lbs	22.3 lbs	44.5 lbs
50 ppm	4.75 oz	11.9 oz	3.71 lbs	7.42 lbs	14.8 lbs	37.1 lbs	74.2 lbs

Volume of Water							
Desired Decrease in ppm	2000 L	4000 L	20,000 L	40,000 L	80,000 L	100,000 L	400,000 L
1 ppm	3.5 g	7.11 g	35.6 g	71.1 g	142 g	178 g	711 g
2 ppm	7.11 g	14.2 g	71.1 g	142 g	284 g	356 g	1.42 kg
3 ppm	10.7 g	21.3 g	107 g	213 g	427 g	533 g	2.13 kg
4 ppm	14.2 g	28.4 g	142 g	284 g	569 g	711 g	2.84 kg
5 ppm	17.8 g	35.6 g	178 g	356 g	711 g	889 g	3.56 kg
10 ppm	35.6 g	71.1 g	356 g	711 g	1.42 kg	1.78 kg	7.11 kg
15 ppm	53.3 g	107 g	533 g	1.07 kg	2.13 kg	2.67 kg	10.7 kg
20 ppm	71.1 g	142 g	711 g	1.42 kg	2.84 kg	3.56 kg	14.2 kg

# TABLE D

## To Increase pH Using Soda Ash (Sodium Carbonate, 100%) with the Taylor Base Demand Procedure

Volume of Water							
Drops of Taylor Base Demand Reagent	400 gallons	1000 gallons	5000 gallons	10,000 gallons	20,000 gallons	50,000 gallons`	100,000 gallons
1 drop	0.21 oz	0.51 oz	2.56 oz	5.13 oz	10.3 oz	1.60 lbs	3.20 lbs
2 drops	0.41 oz	1.03 oz	5.13 oz	10.3 oz	1.28 lbs	3.20 lbs	6.41 lbs
3 drops	0.62 oz	1.54 oz	7.69 oz	15.4 oz	1.92 lbs	4.81 lbs	9.61 lbs
4 drops	0.82 oz	2.05 oz	10.3 oz	1.28 lbs	2.5 lbs	6.41 lbs	12.8 lbs
5 drops	1.03 oz	2.56 oz	12.8 oz	1.60 lbs	3.20 lbs	8.01 lbs	16.0 lbs
6 drops	1.23 oz	3.08 oz	15.4 oz	1.92 lbs	3.85 lbs	9.61 lbs	19.2 lbs
7 drops	1.44 oz	3.59 oz	1.12 lbs	2.24 lbs	4.49 lbs	11.2 lbs	22.4 lbs
8 drops	1.64 oz	4.10 oz	1.28 lbs	2.56 lbs	5.13 lbs	12.8 lbs	25.6 lbs
9 drops	1.85 oz	4.61 oz	1.44 lbs	2.88 lbs	5.77 lbs	14.4 lbs	28.8 lbs
10 drops	2.05 oz	5.13 oz	1.60 lbs	3.20 lbs	6.4 lbs	16.0 lbs	32.0 lbs

Volume of Water							
Drops of Taylor Base Demand Reagent	2000 L	4000 L	20,000 L	40,000 L	80,000 L	100,000 L	400,000 L
1 drop	7.68 g	15.4 g	76.8 g	154 g	307 g	384 g	1.54 kg
2 drops	15.4 g	30.7 g	154 g	307 g	614 g	768 g	3.07 kg
3 drops	23.0 g	46.1 g	230 g	461 g	922 g	1.15 kg	4.61 kg
4 drops	30.7 g	61.4 g	307 g	614 g	1.23 kg	1.54 kg	6.14 kg
5 drops	38.4 g	76.8 g	384 g	768 g	1.54 kg	1.92 kg	7.68 kg
6 drops	46.1 g	92.2 g	461 g	922 g	1.84 kg	2.30 kg	9.22 kg
7 drops	53.8 g	108 g	538 g	1.08 kg	2.15 kg	2.69 kg	10.8 kg
8 drops	61.4 g	123 g	614 g	1.23 kg	2.46 kg	3.07 kg	12.3 kg
9 drops	69.1 g	138 g	691 g	1.38 kg	2.76 kg	3.46 kg	13.8 kg
10 drops	76.8 g	154 g	768 g	1.54 kg	3.07 kg	3.84 kg	15.4 kg

# TABLE E

## To Decrease pH Using Muriatic Acid (20° Baumé /31.45% Hcl) with the Taylor Acid Demand Procedure

Volume of Water							
Drops of Taylor Acid Demand Reagent	400 gallons	1000 gallons	5000 gallons	10,000 gallons	20,000 gallons	50,000 gallons	100,000 gallons
1 drop	0.37 fl oz	0.92 fl oz	4.58 fl oz	9.16 fl oz	1.15 pts	1.43 qts	2.86 qts
2 drops	0.73 fl oz	1.83 fl oz	9.16 fl oz	1.15 pts	1.15 qts	2.86 qts	1.43 gal
3 drops	1.10 fl oz	2.75 fl oz	13.7 fl oz	1.72 pts	1.72 qts	1.07 gal	2.15 gal
4 drops	1.47 fl oz	3.67 fl oz	1.15 pts	1.15 qts	2.29 qts	1.43 gal	2.86 gal
5 drops	1.83 fl oz	4.58 fl oz	1.43 pts	1.43 qts	2.86 qts	1.79 gal	3.58 gal
6 drops	2.20 fl oz	5.50 fl oz	1.72 pts	1.72 qts	3.44 qts	2.15 gal	4.30 gal
7 drops	2.57 fl oz	6.41 fl oz	1.00 qts	2.00 qts	1.00 gal	2.51 gal	5.01 gal
8 drops	2.93 fl oz	7.33 fl oz	1.15 qts	2.29 qts	1.15 gal	2.86 gal	5.73 gal
9 drops	3.30 fl oz	8.25 fl oz	1.29 qts	2.58 qts	1.29 gal	3.22 gal	6.44 gal
10 drops	3.67 fl oz	9.16 fl oz	1.43 qts	2.86 qts	1.43 gal	3.58 gal	7.16 gal

Volume of Water							
Drops of Taylor Acid Demand Reagent	2000 L	4000 L	20,000 L	40,000 L	80,000 L	100,000 L	400,000 L
1 drop	14. mL	28.6 mL	143 mL	286 mL	573 mL	716 mL	2.86 L
2 drops	28.6 mL	57.3 mL	286 mL	573 mL	1.15 L	1.43 L	5.73 L
3 drops	43.0 mL	85.9 mL	430 mL	859 mL	1.72 L	2.15 L	8.59 L
4 drops	57.3 mL	115 mL	573 mL	1.15 L	2.29 L	2.86 L	11.5 L
5 drops	71.6 mL	143 mL	716 mL	1.43 L	2.86 L	3.58 L	14.3 L
6 drops	85.9 mL	172 mL	859 mL	1.72 L	3.44 L	4.30 L	17.2 L
7 drops	100 mL	200 mL	1.00 L	2.00 L	4.01 L	5.01 L	20.0 L
8 drops	115 mL	229 mL	1.15 L	2.29 L	4.58 L	5.73 L	22.9 L
9 drops	129 mL	258 mL	1.29 L	2.58 L	5.15 L	6.44 L	25.8 L
10 drops	143 mL	286 mL	1.43 L	2.86 L	5.73 L	7.16 L	28.6 L

# TABLE F

## To Decrease pH Using Dry Acid (Sodium Bisulfate, 93.2%) with the Taylor Acid Demand Procedure

Volume of Water							
Drops of Taylor Acid Demand Reagent	400 gallons	1000 gallons	5000 gallons	10,000 gallons	50,000 gallons	50,000 gallons	100,000 gallons
1 drop	0.49 oz	1.23 oz	6.16 oz	12.3 oz	1.54 lbs	3.85 lbs	7.70 lbs
2 drops	0.99 oz	2.46 oz	12.3 oz	1.54 lbs	3.08 lbs	7.70 lbs	15.4 lbs
3 drops	1.48 oz	3.70 oz	1.16 lbs	2.31 lbs	4.62 lbs	11.6 lbs	23.1 lbs
4 drops	1.97 oz	4.93 oz	1.54 lbs	3.08 lbs	6.16 lbs	15.4 lbs	30.5 lbs
5 drops	2.46 oz	6.16 oz	1.93 lbs	3.85 lbs	7.70 lbs	19.3 lbs	38.5 lbs
6 drops	2.96 oz	7.39 oz	2.31 lbs	4.62 lbs	9.24 lbs	23.1 lbs	46.2 lbs
7 drops	3.45 oz	8.63 oz	2.70 lbs	5.39 lbs	10.8 lbs	27.0 lbs	53.9 lbs
8 drops	3.94 oz	9.86 oz	3.08 lbs	6.16 lbs	12.3 lbs	30.8 lbs	61.6 lbs
9 drops	4.44 oz	11.1 oz	3.47 lbs	6.93 lbs	13.9 lbs	34.7 lbs	69.3 lbs
10 drops	4.93 oz	12.3 oz	3.85 lbs	7.70 lbs	15.4 lbs	38.5 lbs	77.0 lbs

Volume of Water							
Drops of Taylor Acid Demand Reagent	2000 L	4000 L	20,000 L	40,000 L	80,000 L	100,000 L	400,000 L
1 drop	18.5 g	36.9 g	185 g	369 g	738 g	923 g	3.69 kg
2 drops	36.9 g	73.8 g	369 g	738 g	1.48 kg	1.85 kg	7.38 kg
3 drops	55.4 g	111 g	554 g	1.11 kg	2.21 kg	2.77 kg	11.1 kg
4 drops	73.8 g	148 g	738 g	1.48 kg	2.95 kg	3.69 kg	14.8 kg
5 drops	92.3 g	185 g	923 g	1.85 kg	3.69 kg	4.61 kg	18.5 kg
6 drops	111 g	221 g	1.11 kg	2.21 kg	4.43 kg	5.54 kg	22.1 kg
7 drops	129 g	258 g	1.29 kg	2.58 kg	5.17 kg	6.46 kg	25.8 kg
8 drops	148 g	295 g	1.48 kg	2.95 kg	5.91 kg	7.38 kg	29.5 kg
9 drops	166 g	332 g	1.66 kg	3.32 kg	6.64 kg	8.31 kg	33.2 kg
10 drops	185 g	369 g	1.85 kg	3.69 kg	7.38 kg	9.23 kg	36.9 kg

# TABLE G

## To Increase Alkalinity Using Baking Soda (Sodium Bicarbonate, 100%)

Volume of Water							
Desired increase in ppm	400 gallons	1000 gallons	5000 gallons	10,000 gallons	20,000 gallons	50,000 gallons	100,000 gallons
10 ppm	0.90 oz	2.24 oz	11.2 oz	1.40 lbs	12.6 lbs	7.00 lbs	14.0 lbs
20 ppm	1.79 oz	4.48 oz	1.40 lbs	2.80 lbs	5.60 lbs	14.0 lbs	28.0 lbs
30 ppm	2.69 oz	6.72oz	2.10 lbs	4.20 lbs	8.41 lbs	21.0 lbs	42.0 lbs
40 ppm	3.59 oz	8.97 oz	2.80 lbs	5.60 lbs	11.2 lbs	28.0 lbs	56.0 lbs
50 ppm	4.48 oz	11.2 oz	3.50 lbs	7.00 lbs	14.0 lbs	35.0 lbs	70.0 lbs
60 ppm	5.38 oz	13.4 oz	4.20 lbs	8.41 lbs	16.8 lbs	42.0 lbs	84.1 lbs
70 ppm	6.28 oz	15.7 oz	4.90 lbs	9.81 lbs	19.6 lbs	49.0 lbs	98.1 lbs
80 ppm	7.17 oz	1.12 lbs	5.60 lbs	11.2 lbs	22.4 lbs	56.0 lbs	112 lbs
90 ppm	8.07 oz	1.26 lbs	6.30 lbs	12.6 lbs	25.2 lbs	63.0 lbs	126 lbs
100 ppm	8.97 oz	1.40 lbs	7.00 lbs	12.6 lbs	28.0 lbs	28.0 lbs	140 lbs

Volume of Water							
Desired increase in ppm	2000 L	4000 L	20,000 L	40,000 L	80,000 L	100,000 L	400,000 L
10 ppm	33.6 g	67.1 g	336 g	671 g	1.34 kg	1.68 kg	6.71 kg
20 ppm	67.1 g	134 g	671 g	1.34 kg	2.69 kg	3.36 kg	13.4 kg
30 ppm	101 g	201 g	1.01 kg	2.01 kg	4.03 kg	5.04 kg	20.1 kg
40 ppm	134 g	269 g	1.34 kg	3.36 kg	5.37 kg	6.71 kg	26.9 kg
50 ppm	168 g	336 g	1.68 kg	3.36 kg	6.71 kg	8.39 kg	33.6 kg
60 ppm	201 g	403 g	2.01 kg	4.03 kg	8.06 kg	10.1 kg	40.3 kg
70 ppm	235 g	470 g	2.35 kg	4.70 kg	9.40 kg	11.8 kg	47.0 kg
80 ppm	269 g	537 g	2.69 kg	5.37 kg	10.7 kg	13.4 kg	53.7 kg
90 ppm	302 g	604 g	3.02 kg	6.04 kg	12.1 kg	15.1 kg	60.4 kg
100 ppm	336 g	671 g	3.36 kg	6.71 kg	13.4 kg	16.8 kg	67.1 kg

# TABLE H

## To Decrease Alkalinity Using Dry Acid (Sodium Bisulfate, 93.2%)\*

Volume of Water							
Desired decrease in ppm	400 gallons	1000 gallons	5000 gallons	10,000 gallons	20,000 gallons	50,000 gallons	100,000 gallons
10 ppm	1.37 oz	3.44 oz	1.07 lbs	2.15 lbs	4.30 lbs	10.7 lbs	21.5 lbs
20 ppm	2.75 oz	6.87 oz	2.15 lbs	4.30 lbs	8.59 lbs	21.5 lbs	43.0 lbs
30 ppm	4.12 oz	10.3 oz	3.22 lbs	6.45 lbs	12.9 lbs	32.2 lbs	64.5 lbs
40 ppm	5.50 oz	13.7 oz	4.30 lbs	8.59 lbs	17.2 lbs	43.0 lbs	85.9 lbs
50 ppm	6.87 oz	1.07 lbs	5.37 lbs	10.7 lbs	21.5 lbs	53.7 lbs	107 lbs
60 ppm	8.25 oz	1.29 lbs	6.45 lbs	12.9 lbs	25.8 lbs	64.5 lbs	129 lbs
70 ppm	9.62 oz	1.50 lbs	7.52 lbs	15.0 lbs	30.1 lbs	75.2 lbs	172 lbs
80 ppm	11.0 oz	1.72 lbs	8.59 lbs	17.2 lbs	34.4 lbs	85.9 lbs	172 lbs
90 ppm	12.4 oz	1.93 lbs	9.67 lbs	19.3 lbs	38.7 lbs	96.7 lbs	193 lbs
100 ppm	13.7 oz	2.151 lbs	10.7 lbs	21.5 lbs	43.0 lbs	107 lbs	215 lbs

Volume of Water							
Desired decrease in ppm	2000 L	4000 L	20,000 L	40,000 L	80,000 L	100,000 L	400,000 L
10 ppm	51.5 g	103 g	515 g	1.03 kg	2.06 kg	2.57 kg	10.3 kg
20 ppm	103 g	206 g	1.03 kg	2.06 kg	4.12 kg	5.15 kg	20.6 kg
30 ppm	154 g	309 g	1.54 kg	3.09 kg	6.18 kg	7.72 kg	30.9 kg
40 ppm	206 g	412 g	2.06 kg	4.12 kg	8.24 kg	10.3 kg	41.2 kg
50 ppm	257 g	515 g	2.57 kg	5.15 kg	10.3 kg	12.9 kg	51.5 kg
60 ppm	309 g	618 g	3.09 kg	6.18 kg	12.4 kg	15.4 kg	31.8 kg
70 ppm	360 g	721 g	3.60 kg	7.21 kg	14.4 kg	18.0 kg	72.1 kg
80 ppm	412 g	824 g	4.12 kg	8.24 kg	16.5 kg	20.6 kg	82.4 kg
90 ppm	463 g	927 g	4.63 kg	9.27 kg	18.5 kg	23.2 kg	92.7 kg
100 ppm	515 g	1.03 kg	5.15 kg	10.3 kg	20.6 kg	25.7 kg	103 kg



# TABLE I

## To Decrease Alkalinity Using Muriatic Acid (20° Baumé / 31.45%)

Volume of Water							
Desired decrease in ppm	400 gallons	1000 gallons	5000 gallons	10,000 gallons	20,000 gallons	50,000 gallons	100,000 gallons
10 ppm	1.02 fl oz	2.56 fl oz	12.8 fl oz	1.60 pts	1.60 qts	3.99 qts	2.00 gal
20 ppm	2.04 fl oz	5.11 fl oz	1.60 pts	2.40 qts	3.20 qts	2.00 gal	3.99 gal
30 ppm	4.09 fl oz	7.67 fl oz	1.20 qts	2.40 qts	1.20 gal	3.00 gal	5.99 gal
40 ppm	4.09 fl oz	10.2 fl oz	1.60 qts	3.20 qts	1.60 gal	3.99 gal	7.99 gal
50 ppm	5.11 fl oz	12.8 fl oz	2.00 qts	3.99 qts	2.00 gal	4.99 gal	9.98 gal
60 ppm	6.13 fl oz	15.3 fl oz	2.40 qts	1.20 gal	2.40 gal	5.99 gal	12.0 gal
70 ppm	7.16 fl oz	1.12 pts	2.89 qts	1.40 gal	2.80 gal	6.99 gal	14.0 gal
80 ppm	8.18 fl oz	1.28 pts	3.20 qts	1.60 gal	3.20 gal	7.99 gal	16.0 gal
90 ppm	9.20 fl oz	1.44 pts	3.59 qts	1.80 gal	3.59 gal	8.99 gal	18.0 gal
100 ppm	10.2 fl oz	1.60 pts	3.99 qts	2.00 gal	3.99 gal	9.98 gal	20.0 gal

Volume of Water							
Desired decrease in ppm	2000 L	4000 L	20,00 L	40,000 L	80,000 L	100,000 L	400,000 L
10 ppm	39.9 mL	79.9 mL	399 mL	799 mL	1.60 L	2.00 L	7.99 L
20 ppm	79.9 mL	160 mL	799 mL	1.60 L	3.20 L	3.99 L	16.0 L
30 ppm	120 mL	240 mL	1.20 L	2.40 L	4.79 L	5.99 L	24.0 L
40 ppm	160 mL	320 mL	1.60 L	3.20 L	6.39 L	7.99 L	32.0 L
50 ppm	200 mL	399 mL	2.00 L	3.99 L	7.99 L	9.98 L	39.9 L
60 ppm	240 mL	479 mL	2.40 L	4.79 L	9.59 L	12.0 L	47.9 L
70 ppm	280 mL	559 mL	2.80 L	5.59 L	11.2 L	14.0 L	55.9 L
80 ppm	320 mL	639 mL	3.20 L	6.39 L	12.8 L	16.0 L	63.9 L
90 ppm	359 mL	719 mL	3.59 L	7.19 L	14.4 L	18.0 L	71.9 L
100 ppm	399 mL	799 mL	3.99 L	7.99 L	16.0 L	20.0 L	79.9 L

# TABLE J

## To Increase Calcium Hardness Using Calcium Chloride (77 %) \*

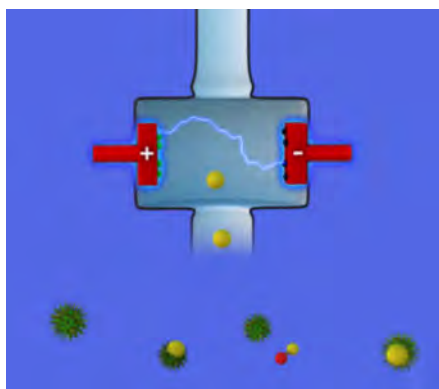
Volume of Water							
Desired increase in ppm	400 gallons	1000 gallons	5000 gallons	10,000 gallons	20,000 gallons	100,000 gallons	400,000 gallons
10 ppm	0.77 oz	1.92 oz	9.61 oz	1.20 lbs	2.40 lbs	6.01 lbs	12.0 lbs
20 ppm	1.54 oz	3.85 oz	1.20 lbs	2.40 lbs	4.81 lbs	12.0 lbs	24.0 lbs
30 ppm	2.31 oz	5.77 oz	1.80 lbs	3.61 lbs	7.21 lbs	18.0 lbs	36.1 lbs
40 ppm	3.08 oz	7.69 oz	2.40 lbs	4.81 lbs	9.61 lbs	24.0 lbs	48.1 lbs
50 ppm	3.85 oz	9.61 oz	3.00 lbs	6.01 lbs	12.0 lbs	30.0 lbs	60.1 lbs
60 ppm	4.62 oz	11.5 oz	3.61 lbs	7.21 lbs	14.4 lbs	36.1 lbs	72.1 lbs
70 ppm	5.38 oz	13.5 oz	4.21 lbs	8.41 lbs	16.8 lbs	42.1 lbs	84.1 lbs
80 ppm	6.92 oz	15.4 oz	4.81 lbs	9.61 lbs	19.2 lbs	48.1 lbs	96.2 lbs
90 ppm	6.92 oz	1.08 lbs	5.41 lbs	10.8 lbs	24.0 lbs	54.1 lbs	108 lbs
100 ppm	7.69 oz	1.20 lbs	6.01 lbs	12.0 lbs	24.0 lbs	60.1 lbs	120 lbs

Volume of Water							
Desired increase in ppm	2000 L	4000 L	20,000 L	40,000 L	80,000 L	100,000 L	400,000 L
10 ppm	28.8 g	57.6 g	288 g	576 g	1.15 kg	1.44 kg	5.76 kg
20 ppm	57.6 g	115 g	576 g	1.15 kg	2.30 kg	2.88 kg	11.5 kg
30 ppm	86.4 g	173 g	864 g	1.73 kg	3.46 kg	4.32 kg	17.3 kg
40 ppm	115 g	230 g	1.15 kg	2.30 kg	4.61 kg	5.76 kg	23.0 kg
50 ppm	144 g	288 g	1.44 kg	2.88 kg	5.76 kg	7.20 kg	28.8 kg
60 ppm	173 g	346 g	1.73 kg	3.46 kg	6.91 kg	8.64 kg	34.6 kg
70 ppm	202 g	403 g	2.02 kg	4.03 kg	8.06 kg	10.1 kg	40.3 kg
80 ppm	230 g	461 g	2.30 kg	4.61 kg	9.22 kg	11.5 kg	46.1 kg
90 ppm	259 g	518 g	2.59 kg	5.18 kg	10.4 kg	13.0 kg	51.8 kg
100 ppm	288 g	576 g	2.88 kg	5.76 kg	11.5 kg	14.4 kg	57.6 kg

# X. Chlorine & Salt Generators

## Chlorine / Salt Generators

Chlorine/salt water generators have become the top alternative sanitizer in the United States over the past 10-15 years or so. Unfortunately, many people mistaken them as a chlorine-free system, when in fact, they make chlorine! People think that by just adding salt to the pool instead of chlorine makes it a chlorine-free pool.

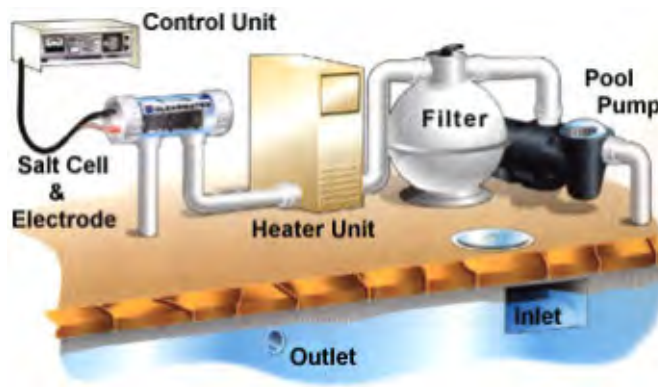


## How they work

Salt water chlorination is a process that uses dissolved salt (1,800-6,000 ppm) as a store for the chlorination system. The chlorinator uses electrolysis to break down the salt ( $\text{NaCl}$ ). The resulting chemical reaction eventually produces hypochlorous acid ( $\text{HClO}$ ) and sodium hypochlorite ( $\text{NaClO}$ ), which are the sanitizing agents already commonly used in swimming pools.

## Types of chlorine generators

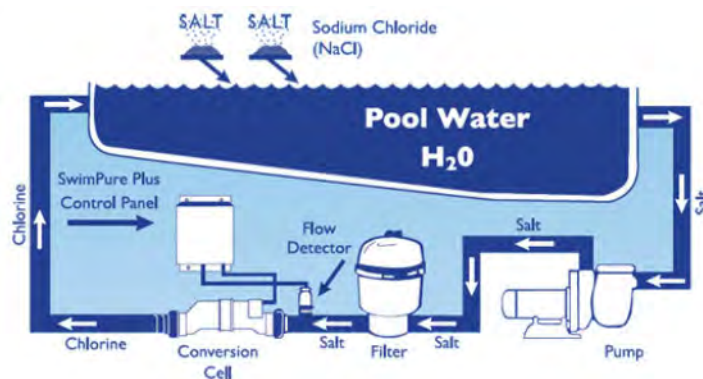
There are two types of chlorine in use today on residential pools. The first one is a brine unit. This unit does not require the pool to have salt added to it. A tank or chamber at the pool equipment has a predetermined amount of salt in it. Through electrolysis, chlorine is produced and immediately injected into the pool circulation system.



The chlorinator cell consists of parallel titanium plates coated with ruthenium and sometimes iridium. These older models make use of perforated (or mesh) plates, rather than solid plates. They also produce by-products that are not simple to dispose of.

The more popular method is the type requiring salt to be added to the pool. There are two types of these units. One has the chlorine-producing cell and the electronics installed at the equipment while the other has the cell installed in the deck near the pool with the electronics usually located at the equipment. The deck unit works on the principle on convection. It make chlorine even if the pump is off while the other more common unit makes chlorine as water is passed through the cell with the circulation system or pool pump on.

The electrolytic process naturally attracts calcium and other minerals to the plates. Thus, depending on water chemistry and magnitude of use, the cell will require cleaning in a mild acid solution which will remove the buildup of calcium. Extremely excessive buildup can reduce the effectiveness of the cell.



As pool water passes through the chlorine generator cell, the salt in the water is turned into hypochlorous acid. This is the exact same components that are produced when any chlorine is added to pool water, whether you use sticks, tablets, granular or liquid. As the water returns to the pool, it will introduce the newly produced chlorine, preventing algae, bacteria and killing microorganisms.

The electrolytic cell, through the use of a small electric current, breaks down the water into its basic elements, hydrogen and oxygen. By adding small quantities of granulated salt (much like household table salt), hypochlorous acid (common chlorine) is produced. During this process, the hypochlorous acid is ultimately converted back to salt. Thus, the salt does not get “used up”, but will need “topping” over periodically to replace salt lost to water splashing and filter backwashing.



## Is the pool a salt water pool?

The salt level required to maintain a safe, chlorinated pool is about 2500 to 4000 ppm. The human body cannot test taste salt until the ppm is around 5000, however many home owners may have levels over that without knowing it. As a reference point, the ocean water is around 33,000-40,000 ppm.

## Advantages

They are attractive to pool owners simply because they eliminate the need to buy, transport, handle and store chlorine. The owner thinks the pool is chlorine free, when in truth, they are chloramine-free. Chloramines are the irritants which give traditional pools the burning eyes and “chlorine” smells in the water. The electrolytic process burns off chloramines in the same manner as traditional shocking with an oxidizer.



## Disadvantages

Down sides are the high initial cost of the system, maintenance, the cost of replacement cells, and the need of salt and cyanuric acid. Salt is corrosive and it will damage some metals and some improperly-sealed stone. Damage usually occurs with improperly maintained pool chemistry or improper maintenance of the electrolytic cell. Pool equipment manufacturers will not warranty stainless steel products damaged by saline pools.

## Disadvantages continued

Calcium and other precipitate buildup will occur naturally on the cathode plate, and sometimes in the pool itself as “scaling”. Regular maintenance of the cell is necessary; failure to do so will reduce the effectiveness of the cell, which will in turn increase the salinity of the water to corrosive levels (as water flowing through the chlorinator will have salt added but not electrolyzed into chlorine). Certain designs of saline chlorinator use a “reverse-polarity” design that will regularly switch the roles of the two electrodes between the anode and the cathode, causing this calcium buildup to dissolve off the accumulating electrode. Such systems reduce, but do not eliminate the need to clean the electrolytic cell and the occurrence of calcium scale in the water.



The replacement cells are expensive and from what other customers tell us, never seen to last as long as they are claimed to. Sometimes these cells can almost as much as the system itself, and need changing every few years or so. Improperly maintained cells will need replacement more often, and many people simply don't have the time or knowledge to take care of the equipment properly.



Salt will need to be added to the pool on a periodic table (after the initial amount is put in), and saltwater pools will require a stabilizer (cyanuric acid) to help stop the sun's UV rays from breaking down the free-chlorine in the pools. These are added costs that will incur as well as a substantial increase in your electric bill if the pool pump needs to be running more hours a day, as is the case for many saltwater pool owners.

Pools or spas with copper pipes are not recommended to use a saltwater system as the salt will eat away at the copper pipe. Many customers also complain it is more difficult to maintain the water chemistry, especially the pH.



# NOTES

# NOTES

