LaMotte

Pool Manager
Water Quality Handbook

Pool Manager
Water Quality Handbook

for aquatic specialists

LaMotte

Water Testing Leader Since 1919!

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Water Analysis

Why?

The pool manager's foremost responsibility is to maintain a safe recreational environment for the swimmer. To assure safety, the pool area must be evaluated regularly for possible sources of injury. To the inexperienced, a missing "No Diving" sign or an insufficient level of chlorine in the water may seem insignificant, but a properly trained pool manager recognizes that these are serious safety violations which require immediate attention.

Maintaining proper water quality is an extremely important part of an overall pool safety program. A water analysis serves three vital purposes: protecting the swimmer, protecting the pool, and protecting against wasteful chemical expenses. In addition, the pool manager balances the water so it is cosmetically clear and clean.

Protecting the swimmer

Every public pool is visited regularly by local health officials who conduct a water analysis while evaluating the overall safety of the pool area. The health official and the pool manager share the responsibility of protecting the swimmer. Cooperating with health officials to ensure that the swimming facility complies with state and local regulations is very important. The pool manager should have a copy of these regulations or codes and be familiar with them.

To prevent exposure to harmful bacteria, the most important water quality test is for adequate levels of sanitizer. Insufficient levels can cause swimmer irritations which may later lead to severe health problems. The most common sanitizers used in pool water are chlorine and bromine.

These are used to prevent bacteria and algae within the pool and will be discussed later in detail. The tests for pH and alkalinity are also very important to the overall safe operation of the pool. Cloudy water, skin and eye irritation all result from improper pH and alkalinity levels in swimming pool water. The pH must also be properly maintained to maximize the sanitizing effectiveness of chlorine. The remaining tests which are performed on pool water are more important to the overall protection of the pool and its mechanical parts.

Protecting the pool

Maintaining a proper pH level is the first step toward protecting the pool. Corrosive conditions, which result from a low pH, can severely damage pool surfaces, plumbing, and cause bad staining problems.

Scale can result from a high pH and can clog waterlines, filters, and leave residues on pool surfaces and parts. By using daily water tests to make proper chemical adjustments, the pool and its parts are better protected, and should last much longer.

Protecting against chemical expense

The most common mistake made in treating pool and spa water is using improper amounts of chemicals. However, there are numerous occasions when chemicals are added in excess of the water's actual need. This contributes to an imbalance in the pool chemistry, which can be harmful to both the swimmer and the pool, and as a result, more chemicals have to be added in order to bring the pool back into balance. In extreme cases swimmers may be restricted from using the pool.

Accurate water analysis should be used to determine which chemicals need to be added. Chemical treatment charts have been provided in the back of this handbook. While there is no substitute for formal instruction in operating a swimming pool, a retail pool professional should be consulted for advice on how to add chemicals.

How?

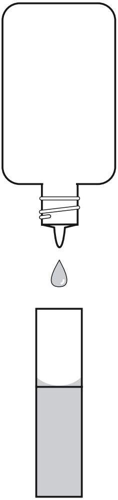
There are a variety of water test kits available to the pool manager. Each has its own unique set of directions which should be read very carefully. Though reagents may look similar from one kit to the next, the color standards in the color comparator or viewer can vary from one manufacturer to another. Therefore, it is important to realize that reagents or procedures are not interchangeable from test kit to test kit.

One of the most ignored, yet vital, directions in every test kit instruction is always to 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.

When using a color comparator always read test results against a 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 plastic or paper behind the comparator when reading results. This procedure will neutralize background interferences which can significantly affect test results.

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. Several “do’s” and “don’ts” are listed on the following page.

Do's



1. Always hold reagent dropper bottles vertically and squeeze gently to obtain a uniform drop size. 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.
4. Keep DPD liquids away from heat.

Don'ts

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

Water Sampling

For best results the analyst should take samples from three to four areas around the pool each day. This can be especially beneficial in larger pools. Keep in mind that samples obtained on the surface should always be avoided since this may not be representative of the actual water chemistry. Several “do’s” and “don’ts” include:

Do’s

1. Rinse the sampling container several times with the water to be tested.

2. Holding the sampling container sides, immerse to elbow depth, approximately 15 inches or more below the surface, keeping the container 6 inches away from the side wall.

3. Always test the water sample promptly after collecting it.

Don’ts

1. Never collect a sample near a make-up water inlet, return area, or next to chemical feeders.

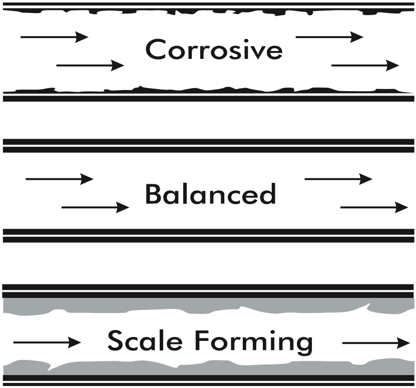
2. Never test a water sample immediately following a shock treatment.

3. Never use a sampling container that is in any way dirty or has a rusty lid—use plastic whenever possible. Glass should not be allowed in the pool area.

Water Balance

Water balance is defined as a condition where the water is neither corrosive nor scale forming. The factors in determining water balance include pH, total alkalinity, calcium hardness, temperature, and total dissolved solids (TDS).

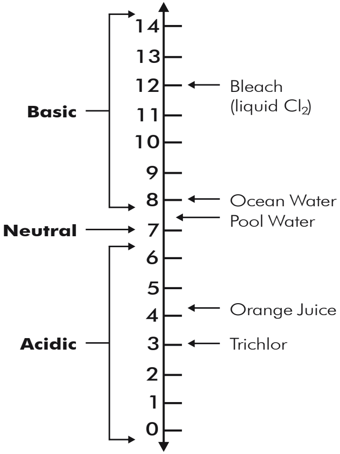
Since water in motion tends to be corrosive, water balance is very important within the pool. To avoid corrosive conditions which can etch pool surfaces and mechanical parts, maintain all water quality factors within the proper range. Proper levels allow the water to become saturated, or non-corrosive, a key goal for prolonged trouble-free pool operation. When pool water becomes oversaturated with dissolved substances, especially calcium salts (primarily calcium carbonate), these substances fall out of solution and can make the water cloudy or deposit on pool surfaces. This is called scale and is a menace to pool surfaces and plumbing fixtures, clogging water lines and filters. As water balance is so important in maintaining the pool surfaces and parts, it constantly needs to be monitored with test equipment.



Pipe diagram

pH

What is pH?



The term pH refers to the concentration of hydrogen ions in water. The pH test determines if a substance is acidic, neutral or basic. A substance with a pH of 7.0 is neutral, neither acidic nor basic. Those with a pH of less than 7.0 are acidic (orange juice has an acidic pH of 4.2). A pH above 7.0 is basic (ocean water is basic with a pH of about 8.0). The ideal pH for pool water is slightly basic, between pH 7.2 and 7.6 This range is most comfortable for the swimmer, protects the pool equipment, and allows sanitizers to work efficiently.

Why Do We Test pH?

The pH test is critical to protecting the pool. Though low or high pH levels can irritate swimmers' eyes or skin, pH is normally considered the best indicator of overall "pool health."

Controlling pH is critical for protecting the pool and its equipment from costly damages due to corrosive/acidic water or scale-forming/basic water.

For an indication of just how the pH affects the overall condition of the pool and its parts, other tests must be performed to obtain a clear answer. These tests are discussed later.

The pool water pH should be tested several times a day in a public pool with moderate-to-heavy swimmer usage. The pool's pH level is constantly being changed by chlorine or other treatment chemical additions. Swimmer usage, additions of fresh make-up water, leaves, and debris can also alter the pH slightly. At a high pH level, chlorine is less effective as a sanitizer.

The obvious reason to test pH is not only to identify a problem but to accurately decide how to remedy the problem. If a water test reveals a highly basic pH, such as 8.2, then the water supply needs to have an acidic substance added to bring the water back down to a pH of about 7.4. This need is called an "acid demand" and can be corrected by adding a liquid acid (muriatic acid) or a dry acid (sodium bisulfate).

If a water test shows an acidic pH level, such as 6.8, then a basic substance should be added to bring the water back up to a pH of about 7.6. This need is called a "base demand" and can be corrected by adding soda ash (sodium carbonate) to the water.

High pH → Acid Demand
Low pH → Base Demand

See pages 49-51 for pH treatment charts.

If pH is too low (Acidic)

- corrosion of pool equipment/staining
- swimming eye irritation
- etching plaster pool surfaces
- chlorine dissipates quickly

If pH is too high (Basic)

- scale accumulates on pool equipment
- cloudy, turbid water
- chlorine sanitizing power is weakened
- swimmer eye irritation

How do we test pH?

pH is one of the most vital tests performed daily on pool water, and it is also one of the most simple to perform. A single liquid or tablet indicator is used to provide a distinct pH color reaction which varies from yellow to deep red. This indicator (called Phenol Red) measures pH from 6.8 to 8.4. State public health codes often require that pH color comparators read to 0.2 pH units or better. Check local regulations to confirm that the on-site test equipment is in compliance.

Testing pH is simple: the test tube or sample cell is rinsed and filled to a specified line with sample water. Phenol red liquid or tablet is added to the sample as specified in the instruction. The sample is capped and mixed. The resulting colored solution is compared to color standards to determine the precise pH level.

Alternative methods of testing pH include two types of instrumentation. One is an electronic colorimeter which analyzes the color development with the phenol red pH test by passing a light beam through the sample. The amount of light that is absorbed by the reacted test sample determines the result, which is indicated by a meter display.

The pH meter relies upon a sensor called an electrode, which is immersed in a water sample. The electrode measures the electrical activity within the solution and displays the pH value. Though the pH electrode needs no phenol red reagent to provide a test result, it does need constant calibration with specific pH solutions (known as buffers) to assure accurate readings.

Paper test strips are not used at most public pools. Although they are utilized in smaller private pools and hot tubs, managers should check the local health regulations before using test papers as their only testing device.

Ideal Range for pH

7.2-7.6

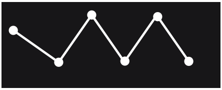
Alkalinity

What is Total Alkalinity?

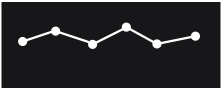
Total alkalinity is a measure of the acid-neutralizing capacity of the water supply which enables it to resist abrupt changes in pH. Total alkalinity is commonly known as a pH stabilizer because, at proper levels, a consistent pH level can be maintained while treatment chemicals or fresh make-up water is added. Commercially available chlorine treatment compounds can range in pH from 3.0 to 13.0, and make-up water can range in pH from 5.0 to 8.0. Therefore maintaining total alkalinity at recommended ranges is extremely important.

Why do we test Alkalinity?

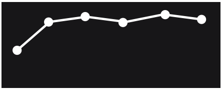
The purpose of testing alkalinity is to determine how susceptible the pool water is to rapid pH changes. A low level of total alkalinity allows the pH to fluctuate or “bounce” when materials are added, even in small amounts. A high level of total alkalinity can have the reverse effect, limiting the ability to change pH levels which may be too high. Total alkalinity is a measure of acid-neutralizing materials in the water, therefore it is normal to see high alkalinity when the pH is also too high. A moderate or ideal alkalinity allows the pH to be maintained without requiring constant chemical adjustments. Alkalinity tests should be conducted once a week.


pH reading

Low Alkalinity
Allows pH to bounce


pH reading

Ideal Alkalinity
Allows proper pH control


pH reading

High Alkalinity
Usually means high pH and is hard to adjust

How do we test Alkalinity?

The level of alkalinity is usually determined using a titration method: an indicator is added to a water sample to produce a distinct color. A weak acid (titrant) is then added slowly until the original color changes. The amount of titrant added to produce the color change determines the result, either by counting the number of drops added or by measuring the volume of titrant. Read the test instruction carefully to determine the proper color change and procedure required. If there is ever doubt in the test result, repeat the test and carefully stop the titration procedure when the endpoint color is reached.

Ideal Ranges for Alkalinity

80-120 ppm • In pools using calcium hypochlorite or sodium hypochlorite

100-150 ppm • In pools using dichlor, trichlor, chlorine gas or bromine

Note: Cyanuric acid contributes to the alkalinity test. The alkalinity reading should be adjusted to compensate for this. Do this by multiplying the cyanuric acid reading by 1/3 and subtracting this from the alkalinity reading.

CYA = 60 ppm
TA = 100 ppm
100 – (60 x 1/3) = 100 – 20 = 80

Thus 80 ppm is the true carbonate alkalinity value that should be used in water balance calculations.

Calcium Hardness

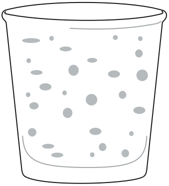
What is Calcium Hardness?

Calcium hardness refers to the level of calcium dissolved in water. If the water has an abundance of calcium, the water is described as “hard”; water with a low content is described as “soft.” The most common source of calcium in pools is fill water, especially if the source or aquifer contains high calcium. When pool water is low in calcium content, calcium may dissolve from plaster surfaces. The term “total hardness” refers to both the calcium and the magnesium content of the water. Do not confuse total hardness test results with those for calcium hardness.

Why do we test Calcium Hardness?

Testing calcium hardness evaluates 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 becomes saturated and the calcium will begin to fall out of the water, settle around the pool, and leave noticeable crusty, white deposits.

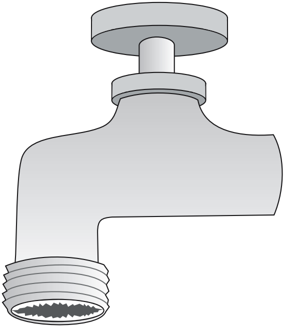


Hard Water
stains dishes and clothes

These deposits are called scale and can be seen on pool parts and walls. Scale can clog filters, heaters, and plumbing fixtures—leading to poor water circulation and costly repairs.

Soft water
leaves items clean and clear

Inadequate levels of calcium hardness also need to be avoided. In plaster pools, aggressive low hardness water can result in etching or pitting in the plaster. Pools with inadequate hardness levels are susceptible to corrosion of metal parts in the pool or heat exchange systems.



Scale can clog pipes

Fortunately water does have a saturation point where it is no longer aggressive and will not deposit scale on pool surfaces, providing maximum protection to the pool surface and its parts. This condition is called "water balance," and can only be obtained when the pH, total alkalinity, calcium hardness, and temperature factors are all at recommended levels.

How do we test Calcium Hardness?

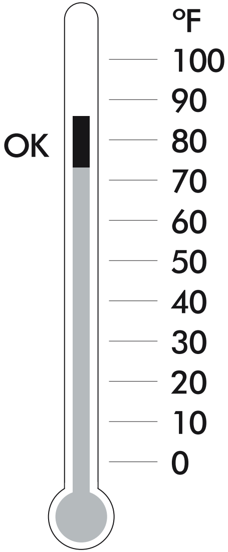
To test calcium hardness a titration procedure is utilized. An indicator is added to the test sample to produce a color indicating the presence of calcium. The sample is titrated with another reagent until a color change occurs and the titration is complete. Next, the result is calculated from the volume of titrant used or is read from a calibrated dispenser or test vial. Always read the test instruction carefully to determine the proper color change and procedure, watching closely for the complete color change from the original color.

Ideal Ranges for Calcium Hardness

Spas: 175-300 ppm
Pools: 200-400 ppm

Temperature

Water temperature is an important comfort factor for swimmers, and for the health of the pool as well. Pool water should be maintained between 75°-85°F. Every pool should have an accurate thermometer for measuring water temperature.



As water warms, the substances within the water become more reactive and aggressive. Higher water temperatures provide an environment where scale and cloudy water are more likely to occur, and evaporation increases.

At cooler temperatures, a pool is prone to corrosion if the water is not properly saturated with minerals.

Water temperature is actually another key element in calculating the pool's saturation index, but plays a smaller role than pH, total alkalinity and calcium hardness. In spas, where water temperatures reach 104°F, it is very important to maintain proper saturation index levels since heaters and other fixtures can be quickly damaged.

Ideal Range for Temperature

Pools: 75°-85°F

Total Dissolved Solids (TDS)

What is TDS?

Total dissolved solids refer to the amount of dissolved substances or minerals (actually charged ions) within the pool. These substances enter the pool either through the original water supply or by the addition of treatment chemicals. As water evaporates total dissolved solids remain behind and increase over time. Distilled water is a solution that contains no dissolved solids. Sea water, on the other hand, contains a vast amount of total dissolved solids.

Due to evaporation and intense chemical treatments, dissolved solids should be closely monitored in spas.

Why do we test TDS?

Water with high TDS readings may be cloudy and cause corrosion. Total dissolved solids should be kept under 2000 parts per million. If TDS exceeds this amount, part of the pool water should be drained and replaced with fresh (low TDS) water.

How do we test TDS?

Most public pools do not have on-site equipment for analyzing total dissolved solids, and a water sample must be taken to a local pool supply retailer who has a TDS meter. A TDS meter measures the electrical conductivity of a water sample. An electrical current is passed between a two-part electrode and the meter then displays the total dissolved solids level. The dissolved minerals in water conduct electricity and a total dissolved solids probe or instrument can be effectively used to measure TDS in parts per million.

Ideal Range for TDS

Less than 2000 ppm. As a general rule TDS should not increase 1500 ppm above the initial start-up amount.

Note: salt chlorine pools will run higher.

Water Sanitizers
Chlorine

What Is Chlorine?

The chlorine used in sanitizing pool water is commercially available in liquid, dry, or gas forms.

The dry form of chlorine is sold as granular, tablet, or stick products. Any form of chlorine, when added to water produces hypochlorous acid (HOCl). Hypochlorous acid kills bacteria, algae, and disease-causing organisms and is commonly referred to as Free Available Chlorine or Free Active Chlorine (F.A.C.). It is the killing power of free chlorine which is important in protecting the swimmer.

The amount of free chlorine available in pool water is significantly affected by pH, sunlight, and impurities.

A high pH level reduces the overall sanitizing power of free chlorine, while sunlight destroys chlorine within water. Nitrogen-containing wastes reduce free chlorine levels by forming less active combined chlorine or chloramines. Combined chlorine has a pungent odor and can become irritating to the swimmer. When the combined chlorine measures 0.2 ppm or more in a pool it is necessary to superchlorinate or shock treat the pool to oxidize the combined chlorine.

Several types of chlorine are used in public pools such as gas or liquid chlorine which are added by automated control-and-release systems.

Chlorine tablets or sticks are also used in public pools by adding them to feeders (never add different types of chemicals to a feeder at the same time). Listed on the next page are the types of chlorine currently available in the United States. Each has a different strength which is represented by % available chlorine.

The pH of each chlorine is given to show how chemical additions can affect your ideal pH of 7.2-7.6.

Ideal Ranges for Chlorine

Pools: 2.0-4.0 ppm
Spas: 4.0-6.0 ppm

Chlorine Treatment Compounds

Trade Name (Proper Name)	% Available Chlorine	pH
Gas (Gas Chlorine)	100%	approx. 2.0
Liquid Chlorine (Sodium Hypochlorite)	5%-5%	13.0
Litho (Lithium Hypochlorite)	35%	10.7
Cal Hypo (Calcium Hypochlorite)	65%-75%	11.8
Dichlor (Sodium Dichloro-s-triazinetrione Dihydrate)	56%	6.0
Dichlor (Sodium Dichloro-s-triazinetrione Anhydrous)	62%	6.0
Trichlor (Trichloro-s-triazinetrione)	90%	3.0

Why do we test Chlorine?

Sanitized water in a public pool is top priority for public health inspectors. Testing and maintaining an adequate level of Free Available Chlorine is a daily goal of the pool manager. Most states require free chlorine levels of at least 1.0 ppm. Tests should be taken several times a day, two to three times under normal bather loads, and more frequently when heavier bather loads are experienced. Local health departments usually have requirements for testing frequency.

Testing for chlorine is not limited to measuring Free Available Chlorine. Regular analyses for the amount of combined chlorine should be made as well. By testing combined chlorine once a day or several times a week, the need for superchlorination can be determined. Combined chlorine can cause chlorine odor and severe eye irritation. A combined chlorine test will indicate that superchlorination is required rather than a simple pH adjustment. Combined chlorine levels should not exceed 0.2 ppm.

How do we test Chlorine?

Prior to the introduction of DPD (diethyl-p-phenylene diamine) in 1969, most chlorinated pools in the United States were tested with OTO (orthotolidine*). OTO is a colorless liquid that produces a yellow color when it reacts with chlorine, and as with most colorimetric tests, the color is proportional to the concentration. Since the test is not suitable for measuring the Free Available Chlorine, its use is not permitted at public pools in almost every state in the nation. Most state health codes specify that a test kit must be on site for measuring Free Available Chlorine, and some even specify that the kit must use the DPD test.

* Orthotolidine is a suspected carcinogen (CA. Prop. 65)

The DPD test method for free chlorine uses either a single foil stripped tablet, identified as DPD #1, or a dual liquid reagent system. In the tablet system one Chlorine DPD #1 tablet is added to a measured water sample in a tube and mixed to disintegrate the tablet. Color develops from a faint pink to a vivid red, depending on the concentration of free chlorine, and is matched to standards with known values in a comparator.

The dual liquid reagent system produces virtually the same color reaction after drops of each solution are added to the test sample. In either DPD test, if a pink color vanishes, that indicates extremely high chlorine levels (>10 ppm).

To obtain a reading for Combined Chlorine the DPD #3 tablet or DPD #3 liquid is added to the original free chlorine test sample. The result is read as Total Chlorine and the increase in color represents combined chlorine.

Example:

Total Chlorine		Free Chlorine		Combined Chlorine
2.0	–	1.5	=	0.5

If the combined chlorine is above 0.2 ppm, superchlorination or a shock treatment should be considered to achieve "breakpoint chlorination"†. A chlorine-based treatment should be used if free chlorine is too low. If additional free chlorine is not needed, an oxygen-based shock treatment can be utilized to eliminate combined chlorine.

† Breakpoint is achieved by multiplying the combined chlorine level times 10. Dose the resulting amount in ppm.

"Shocking" the Pool

Pool water that contains combined chlorine (chloramines) and other organic contaminants such as deodorants and lotions must be treated to keep the water clear and sanitary. There are two primary treatment processes for "shocking" pool and spa water:

1. Use a liquid or granular chlorine compound in a concentrated or excessive amount to increase the free chlorine to a level high enough to break down the undesirable chloramines and organics. In most cases, the chlorine level is raised to 10 ppm (about 5 times the normal level). Following a high chlorine shock treatment, the pool is often closed for 6-12 hours to allow chlorine levels to return to normal. 4 ppm is considered a safe concentration for re-entry into the pool.
2. "Non-chlorine" shock is a chlorine-free persulfate-based compound which is designed to eliminate undesirable combined chlorine. This type of treatment has the unique advantage of allowing bathers to return to the pool shortly after use, but does not increase Free Chlorine levels.

Fecal, vomit or blood accidents

If fecal matter, vomit or blood enters the water, immediately evacuate the pool and remove as much of the material as possible. The pool should then be closed and treated with at least 10 ppm chlorine. Pool managers should train all personnel on the guidelines for treating such accidents. These may be obtained from local health officials or from the Center for Disease Control website (http://www.cdc.gov/healthywater/swimming/).

A note about superchlorination

Some organic chlorine compounds cannot be oxidized by shock or superchlorination. These are sometimes referred to as nuisance compounds. Usually the concentration of these is very minimal, but they do contribute to the combined chlorine reading.

Cyanuric Acid

What is Cyanuric Acid?

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. Cyanuric acid is a chemical that bonds to free available chlorine, enabling it to sanitize the water while being protected from the sun.

Cyanuric acid is primarily available in granular or powdered forms and is usually added through the skimmer. However, there are "stabilized chlorine" compounds (dichlor and trichlor) that already include cyanuric acid. These allow the pool operator to avoid making periodic additions of cyanuric acid. A considerable majority of home pool owners now utilize stabilized forms of chlorine in outdoor pools.

Why do we test Cyanuric Acid?

Like any chemical additive, cyanuric acid must be periodically checked to determine if the pool contains sufficient levels. Insufficient levels of cyanuric acid will not protect the free available chlorine from sunlight. Most state public health standards dictate that 100 ppm is the maximum level of cyanuric acid permitted in swimming pools. While ideal levels are 30-50 ppm, an upper limit of 100 ppm was established because cyanuric acid can only be reduced by pool water removal, replacement, or by "splash-out." Sometimes very large amounts of cyanuric acid can build up if stabilized chlorine compounds are used regularly over long periods of time.

Public pools can be closed by local health agencies if they are not maintained below the maximum level.

How do we test Cyanuric Acid?

Test results are determined by the degree of cloudiness or turbidity that develops when a test reagent is reacted with cyanuric acid. The amount of turbidity indicates the level of cyanuric acid, with low readings being more transparent and high readings being very cloudy.

The cyanuric acid test is usually made by viewing the reacted test sample in a special reading tube containing a black dot on the bottom. The reacted sample is dispensed into the tube to a point where the black dot disappears from sight. At this point the depth of the solution indicates the cyanuric acid concentration. In most test kits the values for concentration in ppm are displayed on the side of the tube.

The analyst should always keep in mind that cold or hot water samples will interfere with the test results. It is best to test samples between 70°-85°F.

Ideal Range for Cyanuric Acid

30-50 ppm (maximum level 100 ppm)

Note: Cyanuric acid contributes to the alkalinity test. The alkalinity reading should be adjusted to compensate for this. Do this by multiplying the cyanuric acid reading by 1/3 and subtracting this from the alkalinity reading.

CYA = 60 ppm
TA = 100 ppm
100 – (60 x 1/3) = 100 – 20 = 80

Thus 80 ppm is the true carbonate alkalinity value that should be used in water balance calculations.

Bromine

What is Bromine?

Bromine is a sanitizer sometimes used in place of chlorine, particularly in hot water systems. In the same way that chlorine forms hypochlorous acid, bromine in water forms hypobromous acid. It is introduced into water using one of three systems:

1. A two-step system uses a bromide salt added to the water as sodium bromide, which is oxidized to hypobromous acid by monopersulfate compounds, chlorine or ozone.
2. Electrolytic generators can convert bromide salt to bromine.
3. The third system uses a stick or briquette that contains chlorine and bromine. This is called BCDMH†. When bromine reacts, it forms a bromide ion. The chlorine in BCDMH reacts with the bromide to regenerate bromine. In 1999 a similar product was introduced, dibromodimethylhydatoin (DBDMH), which does not contain chlorine. Both of these bromine products are usually erosion-fed in an automatic feeder.

Bromine, like chlorine, may be degraded by sunlight.

Bromine destroys bacteria, algae, and water-borne diseases in much the same way that chlorine sanitizes water. Like chlorine, bromine forms free available bromine and combined bromine or bromamines. Combined bromine is a very active sanitizer, and unlike combined chlorine, does not have the pungent odor of combined chlorine.

† 1-bromo-3-chloro-5,5-dimethylhydantoin

Why do we test Bromine?

Since the test for adequate sanitizer is always the most important for protecting swimmer health, the bromine test is vital. When used, a minimum bromine residual of 3 ppm should be maintained within the pool which will assure proper levels of sanitization within the water. Always monitor bromine frequently during periods of heavy bather use.

How do we test Bromine?

Operators should use DPD to test bromine. This is read against color standards in a visual comparator. Since Free Bromine and Combined Bromine are similar in sanitizing strength, they both react with a DPD #1 tablet or 1A and 1B liquids. This reading represents the level of Total Bromine.

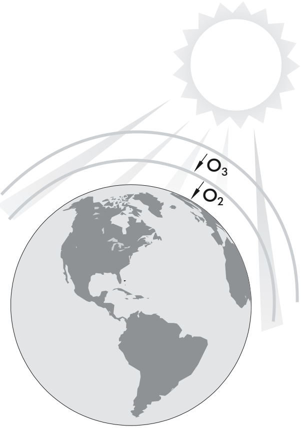
If a bromine comparator is not available, operators can use a chlorine comparator and multiply the reading by 2.25 to calculate ppm bromine. But for best results, a bromine comparator should be used.

Ideal Ranges for Bromine

Pools and Spas: 3-6 ppm

Ozone

What is Ozone?



Most people think of ozone as a layer of gas up above the earth which diffuses and protects us from harmful ultraviolet radiation. That ozone layer is actually made by sunlight striking oxygen molecules (O_2) and adding another atom of oxygen to produce ozone (O_3). Ozone can also be produced when an intense electrical discharge splits the oxygen molecules, such as lightning and photocopy processing. Both produce relatively low levels of ozone which are quickly diffused by the atmosphere.

There are two types of ozone generators for pools being manufactured today: the ultraviolet (UV) method, and the electrical discharge method (commonly known as corona discharge). The UV method uses special UV light bulbs which produce a specific bright light to break up oxygen molecules in the air blown past the bulbs and into the water. The corona discharge method utilizes high voltage electrical charges in a confined space where compressed air is forced through the chamber and into the water.

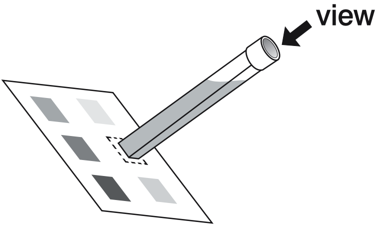
Ozone is an effective oxidizer but it dissipates quite rapidly. Because of this, ozone must be used in combination with chlorine or bromine to meet public pool health requirements.

Ozone is very effective against organics and can help to eliminate organic combined chlorine compounds.

Why do we test Ozone?

Ozone is generated and added to pool water in a bubbling fashion. If a UV lamp or discharge system should malfunction, the air may still be flowing into the water but without the required ozone residuals. As long as some ozone is going into the water, most experts agree that the oxidation process is being properly accomplished. As little as 0.001 parts per million (ppm) has been determined to be effective.

How do we test Ozone?



Because ozone is required at such low levels and it dissipates in minutes after being produced, it can be quite difficult to determine the ozone content of water. Most current testing is done with the DPD test method which produces a pink color in proportion to the amount of ozone in the water sample. However, DPD will also react with any chlorine or bromine in the water.

Another test method is the indigo-trisulfonate method. This method is best suited for use with electronic colorimeters since visual color distinction is extremely difficult for measuring at the low levels of 0.01 ppm.

Ideal Range for Ozone

0.01-0.1 ppm

Alternative Sanitizing Systems

Before using any alternative sanitizing system check with the local health department for compliance and regulations. Most limit use in public pools.

Metal Systems

There are systems that introduce metals or combinations of metals such as copper, silver or zinc into water to inhibit bacteria and algae. There are 3 ways these can be added to the water.

1. Some systems are copper and silver electrodes that use an electrical current to release copper and silver into the water.
2. Some systems are mineral beds that contain metals. Water passes through the bed, the metals dissolve and are added to the water.
3. One can add metals to water by adding them directly as a liquid. Copper sulfate and silver oxide are examples of these.

In public pools chlorine or bromine must be used with metal systems. Zinc and silver are usually not tested in these systems. Copper concentrations can vary from 0.3 to over 1.0 ppm. Color comparators or test strips are used to determine copper concentrations. Follow the manufacturer's recommendations.

Biguanide Systems

Polyhexamethylene biguanide (PHMB) is a bactericide used in a 3 part system. The EPA has approved this system for use as a recreational water sanitizer. The other 2 parts of the system are an algicide (quaternary ammonium compound (QAC) or a polyquat) and hydrogen peroxide, which serves as an oxidizer. Chlorine, bromine, metals or monopersulfate should not be used with this system.

The recommended concentration of PHMB is 30-50 ppm. Test strips and color comparators may be used to test PHMB.

Regular maintenance doses of the algicide and oxidizer are recommended. Check the manufacturer's recommendations for dosages.

Salt Chlorinators

Chlorine can be produced by applying a low voltage direct current to salt (sodium chloride). If sodium bromide salt is used, bromine will be produced.

The salt can be in a separate brine tank or in the pool water. There are minimum concentrations of salt required, usually 2,000-6,000 ppm – follow the manufacturer's recommendations. It is also important to size the units properly so that enough halogen is produced to meet the demand.

To test the salt concentration, one can use a field kit, Salt PockeTester or a test strip.

Hot Water

The chemistry of pools and spas is similar, but there are some things to keep in mind when working with hot water systems. Since there is a much smaller volume of water, the bather load is much higher. This leads to an increase in bacteria and waste products. Chemical reactions are faster at higher temperatures. Calcium carbonate is less soluble, so the tendency for scaling and cloudy water is greater. Particular consideration must be given to the heater element, where the water temperature is higher than the rest of the spa. Scale will form on this before it forms elsewhere in the system. The higher temperatures also provide a better environment for some bacteria. *Pseudomonas* is a type of bacteria that frequently causes skin rashes in hot water. Because of this, hot water systems need higher sanitizer concentrations and should be shocked regularly.

Jetted spas and tubs can force carbon dioxide from the water. This causes the pH to increase. Because of evaporation and chemical addition, the TDS will increase faster than in a pool. TDS is a good way to determine when a spa or hot tub should be drained. If the TDS exceeds 1,500 ppm from the TDS at start-up, it is a good idea to drain and refill.

Hot water systems should be kept below 104°F. Small children and expectant mothers should limit their time in hot water environments. As always, check the local health department regulations.

Pool Problem Solver

Algae

Algae is probably the most annoying water problem in outdoor pools since it is so unsightly and difficult to destroy. Daily brushing and several treatments may be required to successfully eliminate an algae problem. Algae multiplies rapidly, so by the time the human eye can notice it there are billions of algae cells in the pool.

The two most frequent complaints received about public pools are related to algae and cloudy water (the three most common colors of algae are green, black and yellow/mustard). Green algae can make a pool especially cloudy. Algae can clog filter systems and make pool surfaces slippery. The best way to avoid an algae problem is to keep at least 2.0 ppm of free available chlorine circulating throughout the pool water at all times. For persistent algae problems, an algicide may be used.

Nitrate and Phosphate

Nitrate and Phosphate are the two building blocks for algae. Nitrates may enter the water from leaves or debris but other sources of nitrates include well water supplies and localized spraying of lawn or crop fertilizers. Because nitrates can only be removed by draining the water, some manufacturers have focused on removing the other algae nutrient, phosphate. Phosphate can occur naturally, come from fertilizers, municipal water supplies, or from the breakdown of phosphate-based sequestering agents. A variety of phosphate removal systems have been introduced to eliminate the potential for algae.

Ideal Ranges

Pools and spas: <10 ppm Nitrate
Pools and spas: <100 ppb Phosphate

Algae

Color		
Green Algae	**Black Algae**	**Mustard Algae**
Pea green color. Sometimes colors entire body of water. Also attaches to pool surfaces.	Better known as “black spots” on pool walls & surfaces.	A yellow film usually found on steps or walls.
Cause		
Insufficient or inactive levels of sanitizer. Inadequate water circulation. High nitrate and phosphate levels.		
Treatment		
• Check pH & adjust if necessary • Shock treat pool water • Brush surfaces if necessary • Retest pH & repeat treatments if necessary	• Brush affected areas thoroughly • Spot treat affected areas with sanitizer • Shock treat pool water to 30 ppm chlorine and later add algicide • Brush & vacuum as necessary	• Brush affected areas thoroughly • Spot treat affected areas with sanitizer • Shock treat pool water and later add algicide • Retest pH & repeat treatments if necessary

Note: There are a number of specialized algae treatments on the market. If the problem is persistent, ask a pool professional about these.

Cloudy Water

Cloudy pool water is a common problem in swimming pools. The usual causes are improper filtration, and/or improperly balanced water. An algae condition or severe chloramine condition can also cloud pool water.

If a cloudy water condition should occur, check the filter system for clogs and/or damage and determine if adequate flow rates exist. In moderate to heavily used pools a minimum six hour turnover rate is usually suggested. This means that every six hours the entire body of pool water has been recirculated through the filter system. Clogged filters can often be cleared by backwashing.

After a thorough evaluation of the filter system, the water balance should be checked. Look for signs of high calcium hardness, high pH and alkalinity levels.

Filtration

Sand Filters: Check the sand for gaps or hard spots and/or replace the sand. Generally sand should be replaced every 3-5 years.

DE Filters: Soak the “fingers” in a filter cleaner. If the filter is a grid-type filter, hose the grids off and inspect them for damage.

Cartridge Filter: Replace dirty cartridges with clean ones and clean the dirty ones for the next replacement.

Consider contacting your service pro for advice before investigating a suspected filter problem.

Cloudy Water

Cause			
Poor filtration	Algae Growth	Unbalanced Water	
Confirmation			
Slow filter turnover rates	Hazy pool water with slightly green appearance	HIGH • Calcium hardness • TDS • Cyanuric acid	LOW • pH • Alkalinity
Treatment			
• Backwash and clean filter • Determine if filter media needs replacement • Run filter for 24 hours	• Super-chlorinate to 30 ppm chlorine and brush pool surfaces	• Replace a portion of the pool water with fresh water of low hardness and TDS	• Add dry acid or liquid acid to reduce pH to 7.2-7.6 and alkalinity to 80-120

Note: Consult a pool professional if a cloudy condition persists. Repeated treatments or the use of a clarifier may be recommended.

Colored Water

Clear, colorless pool water is the goal, but sometimes it is difficult to achieve. Colored water is a nuisance caused by oxidized metals and algae, and can result in stained pool surfaces. A turbid green pool water condition is usually attributed to algae. To gain a better understanding of algae treatment see the section on algae.

Water color resulting from oxidized metals is translucent in its early stages. Green, red, brown, and black are some of the more common colors produced by dissolved metals. Green, red or brown colors are usually produced by iron. Blue or blue-green water is due to copper. Brown or black color is usually due to manganese, but iron can also cause these colors. These metals can come from the water source or result from corrosion of pipes or fixtures.

Green?
Red?
Brown?
Black?

Often these colored water conditions appear after a pool is first filled or after a shock treatment. If the fill water contains metals it should be treated with a sequestering agent and filtered prior to chlorine additions. A shock treatment can cause metals to oxidize which allows them to fall out of solution and become more visually apparent.

Colored Water

Color		
Green/Red/Brown	Blue/Green	Brown/Black
Cause		
Iron	Copper	Manganese
Treatment		
• Brush • Vacuum • Adjust pH & alkalinity to recommended ranges • Add sequestering agent & run filter • Retest metals, pH & alkalinity. Test hardness levels, and if necessary, raise to 200 ppm		

Note: Take a pool sample to a pool professional for dissolved metals testing immediately after treatment and at least once a month.

Stains

When stains appear on swimming pool surfaces immediate action should be taken to avoid costly and annoying repairs. Brushing can often remove fresh stains. Neglected stains in plaster pools may ultimately require draining the pool and applying an acid wash to the surfaces. Like colored water, stains are the result of metal ions in pool water and they indicate that either the source water contains metals (such as copper, iron and manganese) or that a corrosive pool water condition is dissolving metal pool components.

After noticing a pool stain, determine what caused it by testing the water for metals. If the test indicates a metal problem, the pH should be adjusted to be within the proper range of pH 7.2-7.6. If the problem persists, add a sequestering agent to chemically bind the metals to keep them from causing staining problems.

Stains

Color		
Green/Red/Brown	Blue/Green	Brown/Black
Cause		
Iron	Copper	Manganese
Treatment		
• Adjust pH & alkalinity to recommended ranges • Vigorously brush the stained areas • Add sequestering agent and run filter • Retest metals, pH, and alkalinity. Test hardness levels, and if necessary raise to 200 ppm		

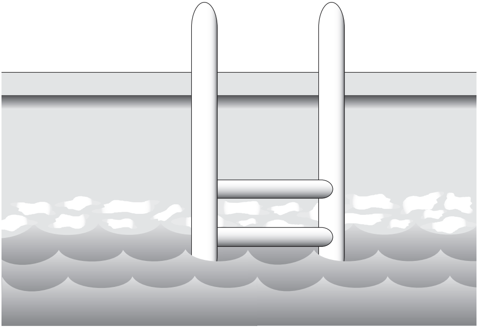
Note: Take a pool sample to a pool professional for dissolved metals testing immediately after treatment and at least once a month.

Scale

Crusty white deposits on pool surfaces indicate a severely high level of one or more water balance factors. Scale deposits not only make pool surfaces rough, but also reduce water circulation by building up within the filter and plumbing system.

If scale deposits are readily noticeable on pool surfaces, pH, calcium hardness, and total alkalinity must be tested and adjusted immediately. One, if not all three, is much too high and needs to be reduced. Reduce the pH and alkalinity levels first, because reducing the calcium hardness level is difficult.

If high hardness or total dissolved solids is causing the scale, it is best to drain a portion of the pool water and replace it with fresh make-up water low in hardness and total dissolved solids.



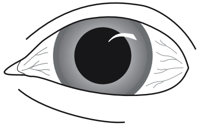
Scale formation on pool walls.

Scale

Confirmation
Crusty deposits on pool surfaces
Cause
• High calcium hardness • High pH and alkalinity • High TDS
Treatment
• Adjust pH and alkalinity to ideal ranges (7.2-7.6 and 80-120 ppm respectively) • Replace a volume of pool water with water low in hardness and dissolved solids. Consult a pool professional to determine the replacement amount • Use a sequestering agent to prevent scale build-up if high hardness levels are a continuing problem

Eye & Skin Irritations

Eye and skin irritations are another common problem for swimming pool bathers. Nasal irritations can also be noticed in indoor pool areas with poor ventilation and excessive levels of combined chlorine.



There are two basic causes of eye and skin irritations: an improper pH, and a chloramine problem. The human eye is most comfortable in water with a pH of about 7.5. Therefore a pH below 7.2, or above 8.0 can become irritating. Low and high pH levels irritate both eyes and skin.

A chloramine problem is caused when combined chlorine levels exceed 0.2 ppm as determined by a DPD test. Though many people incorrectly blame high chlorine for stinging eyes, it is actually the presence of chloramines which causes this.

Cause	
High or low pH	Combined Chlorine
Treatment	
• Adjust pH to recommended range & test.	• Perform "Breakpoint Chlorination" as noted on page 25.

Water Treatment Tables

Dry chemicals should first be mixed into a small amount of water in increments of about two pounds, and then this pre-dissolved mixture can be distributed evenly around the pool unless directed otherwise.

Precautions:

- Never add water to acid; always add acid to water.
- Never add calcium chloride or other corrosive chemicals to skimmers. These can damage pump and motor elements.
- Always follow manufacturer's recommendations and warnings on product labeling.

Conversions

1 ounce (dry) = 28.35 grams

1 ounce (liquid) = 29.57 milliliters

1 pint = 0.4732 liter

1 gallon = 3.785 liters

1 pound = 453.6 grams

1 foot = 0.3048 meter

Lowering pH with Muriatic Acid*

U.S. Customary Units:

Target 7.4	1,000 Gallons		5,000 Gallons		10,000 Gallons		20,000 Gallons		50,000 Gallons	
pH	**Pt**	**Oz**	**Pt**	**Oz**	**Pt**	**Oz**	**Pt**	**Oz**	**Pt**	**Oz**
7.6-7.8	0	1.3	0	6.4	0	12.8	1	9.6	4	0
7.8-8.0	0	1.9	0	9.6	1	3.2	2	6.4	6	0
8.0-8.4	0	2.6	0	12.8	1	9.6	3	3.2	8	0
>8.4	0	3.2	1	0	2	0	4	0	10	0

Metric Units:

Target 7.4	4000 Liters		20000 Liters		40000 Liters		80000 Liters		200000 Liters	
pH	**L**	**mL**	**L**	**mL**	**L**	**mL**	**L**	**mL**	**L**	**mL**
7.6-7.8	0	41	0	200	0	400	0	800	2	0
7.8-8.0	0	59	0	300	0	600	1	200	3	0
8.0-8.4	0	81	0	400	0	800	1	600	4	0
>8.4	0	100	0	500	1	0	2	0	5	0

* Treatment recommendations are affected by total alkalinity. At low alkalinity levels less acid may be required and at higher alkalinity levels more acid may be required. Read safety precautions when using Muriatic Acid.

Lowering pH with Dry Acid* (Sodium Bisulfate)

U.S. Customary Units:

Target 7.4	1,000 Gallons		5,000 Gallons		10,000 Gallons		20,000 Gallons		50,000 Gallons	
pH	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**
7.6-7.8	0	1.6	0	8	0	16	1	12	5	0
7.8-8.0	0	2.4	0	12	1	4	3	8	8	0
8.0-8.4	0	3.2	0	16	1	12	4	4	10	0
>8.4	0	4	1	4	3	0	5	0	13	0

Metric Units:

Target 7.4	4000 Liters		20000 Liters		40000 Liters		80000 Liters		200000 Liters	
pH	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**
7.6-7.8	0	48	0	240	0	480	0	840	2	400
7.8-8.0	0	72	0	360	0	600	1	980	3	840
8.0-8.4	0	96	0	480	0	840	2	40	4	800
>8.4	0	120	0	600	1	440	2	400	6	240

* Treatment recommendations are affected by total alkalinity. At low alkalinity levels less acid may be required and at higher alkalinity levels more acid may be required.

Raising pH with Soda Ash*

U.S. Customary Units:

Target 7.4	1,000 Gallons		5,000 Gallons		10,000 Gallons		20,000 Gallons		50,000 Gallons	
pH	Lb	Oz	Lb	Oz	Lb	Oz	Lb	Oz	Lb	Oz
7.2-7.4	0	0.6	0	3.2	0	6.4	0	12.8	2	0
7.0-7.2	0	1	0	4.8	0	9.6	1	3.2	3	0
6.8-7.0	0	1.3	0	6.4	0	12.8	1	9.6	4	0
<6.7	0	1.6	0	8	1	0	2	0	5	0

Metric Units:

Target 7.4	4000 Liters		20000 Liters		40000 Liters		80000 Liters		200000 Liters	
pH	Kg	g	Kg	g	Kg	g	Kg	g	Kg	g
7.2-7.4	0	18	0	96	0	192	0	384	0	960
7.0-7.2	0	30	0	144	0	288	0	576	1	440
6.8-7.0	0	39	0	192	0	384	0	768	1	920
<6.7	0	48	0	240	0	480	0	960	2	400

* Treatments in low alkalinity waters require less soda ash while treatments in high alkalinity waters may require more soda ash.

Raising Chlorine 1 ppm

U.S. Customary Units:

	1,000 Gallons	5,000 Gallons	10,000 Gallons	20,000 Gallons	50,000 Gallons
	Oz	**Oz**	**Oz**	**Oz**	**Oz**
Sodhypo*	1 oz	7	13	1.5 pt	2 qt
Lithium	0.4	2	4	8	19
Calhypo	0.2	1	2	4	10
Dichlor †	0.2	1	2	5	12
Dichlor ‡	0.2	1	2	4	11
Trichlor	0.1	1	1.5	3	7

Metric Units:

	4000 Liters	20000 Liters	40000 Liters	80000 Liters	200000 Liters
	grams	**grams**	**grams**	**grams**	**grams**
Sodhypo*	35	165	335	665	1665
Lithium	10	55	115	230	570
Calhypo	5	30	60	125	310
Dichlor †	5	35	70	145	355
Dichlor ‡	5	30	65	130	325
Trichlor	5	20	45	90	220

* This is a liquid and the calculation assumes:
  1 liq. oz. = 1 dry oz., 16 oz. = 1 pint, 32 oz. = 1 quart, 128 oz. = 1 gallon

† dihydrate (56%)

‡ anhydrous (62%)

Routine shock treatments may require a 10 ppm dose while algae problems may require even higher doses. Consult product label before adding any chemical products.

Lowering Alkalinity with Dry Acid

U.S. Customary Units:

	1,000 Gallons		5,000 Gallons		10,000 Gallons		20,000 Gallons		50,000 Gallons	
ppm	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**
10	0	3	1	0	2	0	4	0	10	0
20	0	6	2	0	4	0	8	0	20	0
30	0	10	3	0	6	0	12	0	30	0
40	0	13	4	0	8	0	16	0	40	0
50	1	0	5	0	10	0	20	0	50	0
60	1	3	6	0	12	0	24	0	60	0
70	1	6	7	0	14	0	28	0	70	0
80	1	10	8	0	16	0	32	0	80	0
90	1	13	9	0	18	0	36	0	90	0
100	2	0	10	0	20	0	40	0	100	0

Be sure to note chemical precautions on page 48. Always follow manufacturer's recommendations.

Lowering Alkalinity with Dry Acid

Metric Units:

	4000 Liters		20000 Liters		40000 Liters		80000 Liters		200000 Liters	
ppm	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**
10	0	100	0	480	0	960	1	920	4	800
20	0	190	0	960	1	920	3	840	9	610
30	0	290	1	440	2	880	5	760	14	410
40	0	380	1	920	3	840	7	690	19	210
50	0	480	2	400	4	800	9	610	24	20
60	0	580	2	880	5	760	11	530	28	820
70	0	670	3	360	6	720	13	450	33	620
80	0	770	3	840	7	690	15	370	38	430
90	0	860	4	320	8	650	17	290	43	230
100	0	960	4	800	9	610	19	210	48	30

Be sure to note chemical precautions on page 48. Always follow manufacturer's recommendations.

Lowering Alkalinity with Muriatic Acid

U.S. Customary Units:

	1,000 Gallons		5,000 Gallons		10,000 Gallons		20,000 Gallons		50,000 Gallons	
ppm	**Pt**	**Oz**	**Pt**	**Oz**	**Pt**	**Oz**	**Pt**	**Oz**	**Pt**	**Oz**
10	0	2.5	0	13	1	10	3	4	8	2.5
20	0	5	1	10	3	4	6	8.5	16	0
30	0	8	2	7	4	14	9	12.5	24	0
40	0	10.5	3	4	6	8.5	13	0.5	32	0
50	0	13	4	1	8	2.5	16	0	40	0
60	0	15.5	4	14	9	12.5	19	0	48	0
70	1	2	5	11	11	6.5	22	0	57	0
80	1	5	6	8.5	13	0.5	26	0	65	0
90	1	7.5	7	5.5	14	10.5	29	0	73	0
100	1	10	8	2.5	16	4.5	32	0	81	0

Be sure to note chemical precautions on page 48. Always follow manufacturer's recommendations.

Lowering Alkalinity with Muriatic Acid

Metric Units:

	4000 Liters		20000 Liters		40000 Liters		80000 Liters		200000 Liters	
ppm	**L**	**mL**	**L**	**mL**	**L**	**mL**	**L**	**mL**	**L**	**mL**
10	0	80	0	410	0	810	1	630	4	70
20	0	160	0	810	1	630	3	260	8	140
30	0	240	1	220	2	440	4	890	12	220
40	0	330	1	630	3	260	6	520	16	290
50	0	410	2	40	4	70	8	140	20	360
60	0	490	2	440	4	890	9	770	24	430
70	0	570	2	850	5	700	11	400	28	500
80	0	650	3	260	6	520	13	30	32	580
90	0	730	3	660	7	330	14	660	36	650
100	0	810	4	70	8	140	16	290	40	720

Be sure to note chemical precautions on page 48. Always follow manufacturer's recommendations.

Raising Alkalinity with Sodium Bicarbonate

U.S. Customary Units:

	1,000 Gallons		5,000 Gallons		10,000 Gallons		20,000 Gallons		50,000 Gallons	
ppm	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**
10	0	2.5	0	13	1	10	3	4	8	2.5
20	0	5	1	10	3	4	6	8.5	16	0
30	0	8	2	7	4	14	9	12.5	24	0
40	0	10.5	3	4	6	8.5	13	0.5	32	0
50	0	13	4	1	8	2.5	16	0	40	0
60	0	15.5	4	14	9	12.5	19	0	48	0
70	1	2	5	11	11	6.5	22	0	57	0
80	1	5	6	8.5	13	0.5	26	0	65	0
90	1	7.5	7	5.5	14	10.5	29	0	73	0
100	1	10	8	2.5	16	4.5	32	0	81	0

Be sure to note chemical precautions on page 48. Always follow manufacturer's recommendations.

Raising Alkalinity with Sodium Bicarbonate

Metric Units:

	4000 Liters		20000 Liters		40000 Liters		80000 Liters		200000 Liters	
ppm	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**
10	0	70	0	340	0	670	1	340	3	360
20	0	130	0	670	1	340	2	690	6	720
30	0	200	1	10	2	20	4	30	10	80
40	0	270	1	340	2	690	5	380	13	440
50	0	340	1	680	3	360	6	720	16	800
60	0	400	2	20	4	30	8	60	20	160
70	0	470	2	350	4	700	9	410	23	520
80	0	540	2	690	5	380	10	750	26	880
90	0	600	3	20	6	50	12	100	30	240
100	0	670	3	360	6	720	13	440	33	600

Be sure to note chemical precautions on page 48. Always follow manufacturer's recommendations.

Raising Hardness with Calcium Chloride

U.S. Customary Units:

	1,000 Gallons		5,000 Gallons		10,000 Gallons		20,000 Gallons		50,000 Gallons	
ppm	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**
10	0	2	0	10	1	4	2	7	6	2
20	0	4	1	4	2	7	4	15	12	4
30	0	6	1	13	3	11	7	6	18	7
40	0	8	2	7	4	15	9	13	24	9
50	0	10	3	1	6	2	12	4	30	11
60	0	12	3	11	7	6	14	12	36	13
70	0	14	4	5	8	10	17	3	42	16
80	1	0	4	15	9	13	19	10	49	2
90	1	2	5	8	11	1	22	2	55	4
100	1	4	6	2	12	4	24	9	61	6

A significant amount of heat can be generated when mixing calcium chloride in water. Follow manufacturer's recommendations carefully.

Raising Hardness with Calcium Chloride

Metric Units:

	4000 Liters		20000 Liters		40000 Liters		80000 Liters		200000 Liters	
ppm	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**
10	0	60	0	290	0	590	1	180	2	940
20	0	120	0	590	1	180	2	350	5	880
30	0	180	0	880	1	760	3	530	8	820
40	0	240	1	180	2	350	4	700	11	600
50	0	290	1	470	2	940	5	880	14	700
60	0	350	1	760	3	530	7	60	17	640
70	0	410	2	60	4	120	8	230	20	580
80	0	470	2	350	4	700	9	410	23	520
90	0	530	2	650	5	290	10	590	26	460
100	0	590	2	940	5	880	11	760	29	400

A significant amount of heat can be generated when mixing calcium chloride in water. Follow manufacturer's recommendations carefully.

Establishing or Raising Cyanuric Acid level

U.S. Customary Units:

	1,000 Gallons		5,000 Gallons		10,000 Gallons		20,000 Gallons		50,000 Gallons	
ppm	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**	**Lb**	**Oz**
10	0	1	0	7	0	13	1	11	4	3
20	0	3	0	13	1	11	3	5	8	6
30	0	4	1	4	2	8	5	0	12	8
40	0	5	1	11	3	5	6	11	16	11
50	0	7	2	1	4	3	8	6	20	14

Metric Units:

	4000 Liters		20000 Liters		40000 Liters		80000 Liters		200000 Liters	
ppm	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**	**Kg**	**g**
10	0	40	0	200	0	400	0	800	2	0
20	0	80	0	400	0	800	1	600	4	0
30	0	120	0	600	1	200	2	400	6	0
40	0	160	0	800	1	600	3	200	8	0
50	0	200	1	0	2	0	4	0	10	0

Be sure to note chemical precautions on page 48. Always follow manufacturer's recommendations.

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