Swimming Pool Water Chemistry

The Care and Treatment of Swimming Pool Water

By
John D. Puetz
Director of Technology
Arch Chemicals, Inc., now a part of Lonza

Advantis™ Technologies
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About the Author

John Puetz is the Director of Technology for Arch Chemicals, Inc., now a part of Lonza. John has served for more than 39 years in the pool and spa industry and on numerous advisory panels throughout the industry including:

- Current member and Past President, Board of Directors, National Swimming Pool Foundation
- Past Chairman of the NSPI (National Spa & Pool Institute), now APSP Technical Council
- Past Chairman of the NSPI Chemical Treatment & Process Committee, now APSP Recreational Water Committee

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INTRODUCTION

The maintenance of swimming pool water is multifaceted in the number of factors that must be controlled. More often than not, pool maintenance is simply thought of as needing to periodically add a sanitizer, adjust the pH and run the filter. In reality, swimming pool maintenance is much more than that.

This manual will introduce the basic factors of swimming pool water chemistry. In addition to explaining water chemistry, this reference is intended to address the most important aspect of proper pool maintenance – pool enjoyment.

As pool professionals, it's important that we always keep in mind that our primary responsibility is not the adding of treatment chemicals or the operation of equipment, but rather, to use these tools in the overall goal of providing clean and clear water. After all, our performance as a pool professional is measured largely on how well we prevent problems and keep the water looking inviting, not on how well we solve recurring problems.

Our role in the industry is to help assure that clean and clear water is delivered. We are not here to merely introduce chemicals, sell filters or pumps but, rather, to use these tools to provide desirable water quality results. Rest assured a consumer with an unhappy pool experience is unlikely to purchase another pool or promote pool ownership to someone else. Additionally, if we merely sell customers more and more product in the hopes of providing a solution to a particular problem and in so doing only appear to be guessing at the solution, they will soon grow tired of this endless cycle and move on to a competitor who addresses their needs.

Pool owners or operators will only continue to use our services as long as they are satisfied with the ability to use their pool, not on our ability to eliminate a problem once it has occurred. If our approach to our business is only to react to problems after they occur, then we are not doing the best possible job.

The goal of this manual is to help you do your best job in keeping your customers positive about their pool experience.

Section I will highlight the basic factors of pool water care:

- **Physical Factors**
- **Chemical Factors**
- **Biological Factors**

Then, beginning in **Section II**, the principals of pool maintenance including handling pool chemicals, calculating pool volume, pool start-up, and weekly care are detailed. Additional information on how to Start-up and Winterize is also included.

Although many of these points will likely come as a review for you, the purpose here is to provide this information in a centralized resource that will not only help you manage pool chemistry on the job, but more importantly, help you to gain and keep loyal and satisfied customers.

SECTION I: Basic Factors

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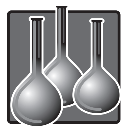
Three basic factors are involved in pool operation. Each of these, when properly managed, will work with the others to provide clean, clear, safe and inviting water. These factors are:

Physical Factors
such as filtration and circulation



Chemical Factors
which include scale and corrosion control

Biological Factors
including sanitization and algae control

Each of these factors requires management primarily to control what is in the water. Consider that even before we put water into a pool, it will contain solids which will require filtration in order for the water to be clear. Additionally, the water may contain naturally occurring minerals such as iron that can stain pool surfaces or calcium that can cause cloudy water or scale and these contaminants will require chemical treatment. Once the water is in the pool, it will be contaminated by rain, wind-blown dust and dirt and even the swimmers contribute to the need for biological control.

A clear understanding of these factors and what is involved in each is critical to recognizing how they can be used to manage the water in a pool. To do this we will review each in detail.

THE PHYSICAL FACTORS INCLUDE:

I. Filtration

II. Circulation & Turnover of the water

III. Other Factors including the control of oily wastes left behind by bathers and the general care for the appearance of pool walls, covers and equipment

Each factor plays an important role that is all too often overlooked or considered unimportant when considering how much a pool will be enjoyed.

When faced with a pool problem, we have a tendency to immediately look into the water chemistry factors. Cloudy water, for example, causes us to question water chemistry when the problem may simply be a filtration issue. The management of the physical factors should be considered the first line of defense in the prevention of pool water problems.

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I. FILTRATION

Filtration is the term used to refer to the mechanical cleaning of pool water. It is an element in pool water maintenance that is frequently overlooked in its importance. One way to think about it would be to consider what it would be like to try to operate a pool without a filter. No amount of chemical treatment would keep the water clear! When operating properly, a filter will remove virtually all particulate matter from the water. These particles of dirt and debris are the result of environmental fallout or are left behind by the bathers and, when not properly filtered out, will cause the water to become hazy and cloudy. The filter will play a very important role even when cloudiness due to a chemical imbalance occurs. By performing properly in removing most of the cloudiness, a fully functional filter will usually allow the water to remain clear enough for continued use of the pool. This gives the pool operator, service person or dealer time to determine the nature of the problem and take corrective action. Since the pool was reasonably clear in spite of the problem, it could remain in use without a panicked customer or need for drastic chemical adjustments.

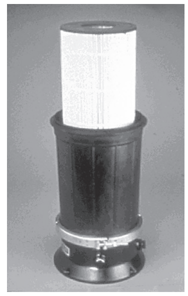
FILTER TYPES

There are three types of filters commonly used on swimming pools:

- Cartridge
- Sand
- Diatomaceous Earth (DE)

While some will argue over which type is "best", each can be effective in keeping water clean and clear. However, they all require proper management in order to gain maximum benefit and service life. A review of how each works and an understanding of how to handle them will be of value.

Cartridge Filters



Cartridge filters consist of pleated fabric, typically polyester, arranged in a cylinder form around a rigid core. The fibers of the polyester trap dirt and oils as the water passes through from around the outside of the cylinder and is returned back through to the pool from the center core. While not regarded as being as efficient as Diatomaceous Earth (DE) filters, cartridge filters are gaining wider use particularly in residential pool applications because they are easy to operate and easily replaced if damaged or worn out.

Cartridge filters will give long and excellent service if they are properly handled. A critical first step in keeping your cartridge operating properly is to keep it clean. Regular rinsing of the cartridge will help in removing large debris and there are spray-on cleaners specially formulated to help remove oily buildup not otherwise removed by simple rinsing with water alone. Periodic deep cleaning is important and will not only assure better looking water but longer life from your cartridge as well. Deep cleaning is best accomplished by using a cleaner specially formulated for pool filters. Such a cleaner should be capable of removing both oily and greasy buildup, as well as minerals such as calcium that may have been deposited on the fabric. A good pool filter cleaner, either specifically made for cartridge filters or one made for all types of filters, will contain a combination of surfactants for oil and grease removal, as well as agents which will readily dissolve away built up minerals.

Another way to help extend cartridge life is to keep two sets, one set in use and a clean set ready to go. This allows you or your customer to quickly exchange the cartridges when needed and to clean the dirty ones at a convenient time. Once cleaned, allow the cartridges to dry before reinstalling them. This allows the fibers to expand and fluff up thus providing more effective filter area. You will also find your cartridges will last longer before requiring replacement.

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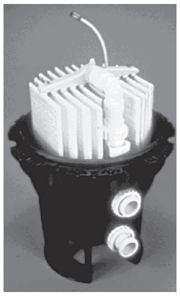
Diatomaceous Earth Filters



Diatomaceous Earth (DE) filters come in a variety of forms. Typically they consist of a fine mesh fabric configured in a variety of shapes or forms including bags, grids or screens and "fingers". DE is a fine white powder composed of the skeletal remains of microscopic organisms that lived millions of years ago. These skeletons are mined from the earth and cleaned. The powder is applied to the surface of the fabric and acts to trap dirt as the pool water passes through it. As the DE becomes clogged with dirt, it is washed off of the fabric and replaced with new DE to begin the process all over.

While DE provides excellent dirt trapping ability, often referred to as the best of the three filter types, the removal and recoating can be a chore and also leaves a disposal problem with the dirty material. As with other filters, the fabric on DE filters must be kept clean. If oils accumulate on the fabric the DE will not adhere properly and the resulting "holes", areas with little or no DE in place, will allow water to pass through without good dirt removal. As with cartridge filters, regular cleaning with a quality pool filter cleaner, either the spray-on or the deep soak type, is needed in addition to the replacement of the DE when it becomes clogged.

Sand Filters

Sand filters, as the name implies, utilize sand as the filtering medium. While there are several types, they all work in much the same way. Sand grains are placed within a filter tank. Water flows down through the sand either under pressure or by vacuum. Consequently, the dirt in the water becomes trapped between the grains of sand. In fact, sand filters rely on some dirt being trapped in the filter. This condition actually improves its ability to remove very small particles.

Sand is regarded as a good filtering media because it does not react to most chemicals. In addition, the particles are irregular in shape so they tend to interlock which creates a fine filtering material.

As sand filters become clogged with dirt, the filter begins to lose its ability to clean the water. This is most often indicated by a change in pressure on the pressure gauge or reductions in flow rate through the filter.

When the flow rate through the filter becomes restricted due to the buildup of dirt and other matter in the sand, a process known as "backwashing" is used. Backwashing involves reversing the flow of water through the filter, which in turn causes the sand and dirt to "loosen". As this process takes place, the loose-trapped dirt will be washed out from between the sand grains and flushed from the filter.

A word of caution, however: backwashing should only be performed when the pressure or flow gauges indicate the need. This is typically no more often than once every week or two.

Consult the filter manufacturer's directions for guidance on when to backwash. Backwashing too frequently will keep the sand so free of dirt buildup that it will not have the ability to remove the smaller particles of dirt (as mentioned above) and they will simply pass through.

The irregular shape of these sand grains, while playing an important role in how a sand filter works, can actually be responsible for loss in filtering efficiency over time. While the irregular shape allows the sand grains to fit together tightly and thus help to trap fine particles of dirt, it can also slowly become imbedded with the buildup of oils, grease and mineral matter removed from the water. In time, this will actually cause the grains to lose their irregular shape and begin to form smooth surfaces, which do not filter as well.

Often sand in this condition is considered old and in need of replacement. However, a good filter cleaner will actually remove this buildup and return the sand to a like-new condition. Sand filters should be cleaned once or twice per year in residential pools, and as often as every 3 months in commercial pools.

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II. CIRCULATION & TURNOVER

Circulation refers to the process of regularly moving all of the pool water through the pump and filter system. In contrast, the term turnover is used to describe how long it takes for a given amount of water to pass through the pump. In other words, when it is said a pool has an eight hour turnover it simply means that when the pump is running it will take eight hours for the net volume of water in the pool to move through the pump and filter system.

It is important to note that turnover does not mean that all of the water in the pool went through the pump and filter. It could be the same water over and over, which is what happens when water is not properly circulating. The growth of black algae can be evidence of slow or "dead spots" in the pool that occur because poor circulation to those areas causes insufficient amounts of sanitizer or algaecide to reach those areas frequently enough to be effective.

There are several things you can do to help assure proper circulation. If the pool has a bottom or main drain, keep it open so that at least 1/3 to 1/2 of the total pool water volume is being drawn through it. The skimmers then handle the rest. Adjust the return line fittings so that they direct the water flow in a generally circular pattern around the pool and also aim them gently downwards to improve water mixing from top to bottom. This last point is critical in pools with no main drain or where the main drain no longer functions due to age or some other problem that is unable to be corrected.

III. OTHER FACTORS

There are several other areas that require attention in order to keep the pool looking inviting and ready for use. These include the removal of tiny particles which may escape filtration and lead to hazy water, and the control of oily wastes that can buildup along the water line or interfere with sanitizers.

CLARIFICATION & FLOCCULATION

Even though we have made certain that the filter is working properly and the circulation pattern is correct, the pool water can still appear hazy or dull. This is most often due to the buildup of what is commonly referred to as microparticles in the water. These particles are so small that they simply pass through the filter media without being trapped. To make matters worse, these particles develop a negative electrical charge and since the charges are all alike, they repel one another and do not clump together, which would otherwise make them easier to filter out. The addition of a water clarifier will solve this problem.

A water clarifier contains a solution of positively charged particles that when added to water, will seek out the negative particles and neutralize their charges. The particles then tend to clump together and are easily filtered out. Used regularly, a clarifier will reduce maintenance, improve filter performance and enhance the appearance of the pool water.

In unusual circumstances of severely cloudy water, such as you may experience at spring opening, the use of a liquid flocculant or "floc" can also be helpful. A floc works similarly to a clarifier; however, instead of helping to remove small particles through the filter, a flocculant coagulates the cloudy water particles into masses that settle quickly to the pool floor so that they can be vacuumed up easily.

A liquid floc can be a real benefit in clearing up severely dirty pools in a short period of time. In contrast to the use of alum based flocs, these materials do not require pH adjustment or result in significant contamination of the water if the circulation system is returned to service before all of the alum has been removed.

CONTROL OF GREASE AND OILS

Proper operation of filtration equipment and circulation systems will go a long way to helping assure a pleasant bathing experience. It must be kept in mind, though, that in addition to the bits of dirt and debris that are easily filtered out, the bather will also leave behind a variety of wastes that can cause other problems in general pool management.

Accumulations of body oils, cosmetics and other complex bather waste can result in the buildup of these materials along the waterline and in pipes and filters. This waste can cause unattractive scum lines and interfere with the performance of the sanitizer, a problem that will affect the overall appearance of the water.

While cleaning products are available for use on scum lines that will keep the waterline clean and bright, it also requires that they be applied manually. Developments in the use of enzyme digestive products now allow us to not only control this waste in the water, but to prevent their buildup on the walls and in

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equipment.

Enzymes are widely used today in both industrial and domestic applications. Many laundry detergents use enzymes to help in the breakdown and removal of stains and deeply-set soil. Enzymes are naturally occurring biological catalysts, which means they help increase the breakdown rate of complex compounds. In pools, specially developed natural based enzymes are used to help break down complex materials like oils and grease. With regular use they will take these very complex and difficult to control materials and break them down into smaller fragments that can be easily destroyed by shock oxidation treatment.

It is important to point out, however, that not all enzymes are well suited to pool use. As stated above, enzymes are naturally occurring substances of biological origin. Since they are manufactured by living organisms and since chlorine and other sanitizers destroy living substances, it is important to select enzymes that can tolerate the typical sanitizer levels commonly found in pools. It is also important to understand that enzymes are highly selective in terms of what substances they will break down. Therefore, one must use enzymes that have been properly selected for digestion of the types of oils and greases found in pool water.

Used as part of a regular maintenance program, enzymes will minimize scum line formation and reduce the frequency for the need to clean the tile line as well as reduce the buildup in pipes and equipment. In addition, the enzyme will help reduce the buildup of these organic wastes on filter media and thus reduce the frequency of cleaning as well as improving water appearance.

CHEMICAL FACTORS

Now that the physical processes are understood, we turn our attention to managing the chemical treatment of the pool water.

Proper chemical treatment is needed in order to prevent a wide range of potential problems including scale and stain formation, colored or cloudy water, corrosion of pool surfaces and equipment and to assure proper performance of the sanitizer being used.

There are five chemical factors that affect water quality. These are listed below in order of importance along with their ideal levels:

	Chemical Factor	*Ideal Level*
I.	**pH**	**7.2-7.8**
II.	**Total Alkalinity**	**80-120 ppm**
III.	**Calcium Hardness**	**100-400 ppm**
IV.	**Stain Producing Minerals**	**Absent**
V.	**Total Dissolved Solids (TDS)**	**250-1500 ppm**

The first three, along with the temperature of the water, determine the overall water balance. Water balance is the term used to refer to the tendency of the water to be either "scale forming" or "corrosive/aggressive."

Water that is referred to as having scale forming tendencies is one that is considered likely to suffer from problems related to high pH, high total alkalinity, hard water (elevated calcium level) or combinations of two or three of these factors. When these conditions are present, it is common for the water to be cloudy and for scale to form on pool surfaces and in equipment.

Corrosive or aggressive water is most commonly associated with chemical factors which are opposite of those above, and this results in destruction of pool walls and corrosion of equipment such as heaters.

In general, maintaining proper chemical levels or values in the pool water will prevent these problems. Problems which can not be controlled by proper water balance alone can be managed using specialty products designed to provide such protection.

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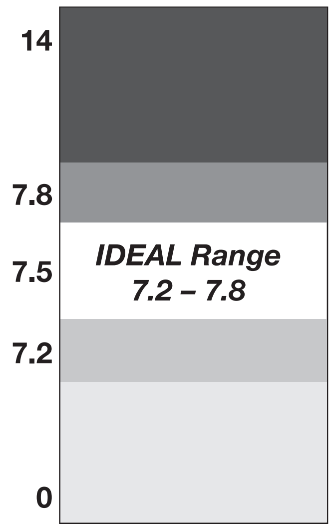
I. pH

pH is the term used to refer to the degree of activity of an acid or base in the water and is the most important chemical factor in swimming pools. pH is measured on a scale from 0 to 14 with 7 being neutral. A pH value between 0 and 7 is considered acidic with 0 being the greatest acid activity and getting weaker as it approaches a value of 7. A value of 7 to 14 is considered basic with 14 being the greatest base activity. Another word for basic is alkaline; however, this is not to be confused with total alkalinity. pH and total alkalinity are not the same.



Pool water pH is best kept in the range of 7.2 to 7.8. When pH remains below 7.2, the water is considered to be corrosive. This means etching of plaster and metals in equipment such as heat exchangers will result. In addition, it is more difficult to keep chlorine in the pool because while more effective as a sanitizer at the low pH, chlorine is also much less stable resulting in the consumption of larger quantities of chlorine than would be used at normal pH levels.

Maintaining the pH higher than 7.8 will increase the tendency to form scale or cloudy water. Calcium, the major component in scale, is a relatively unstable mineral and when the pH is high, the calcium is not as soluble and it will have a greater tendency to precipitate or "fall out" of solution resulting in cloudiness or scale. High pH will also reduce chlorine effectiveness resulting in the need to maintain higher chlorine levels to achieve maximum sanitization. If the pH is low, sodium carbonate, otherwise known as pH Up or soda ash, is added to raise the pH. If the pH is high, pH Down is used. pH Down comes in two forms: liquid acid (muriatic acid) or dry acid (sodium bisulfate).

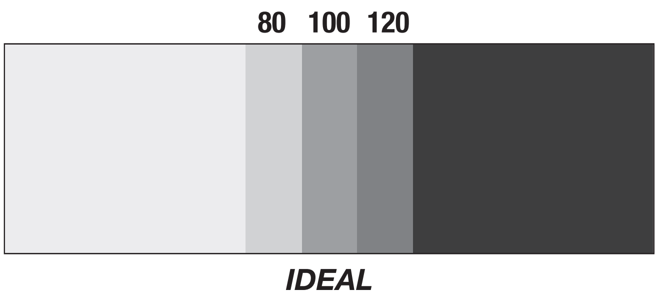
Changes in the pH of pool water can be caused by many factors but the most significant cause is the sanitizer used. Since the sanitizer is the most frequently added chemical in pools, it can have a powerful impact on pH and overall water quality. Of the sanitizers typically used in pools, chlorine is the most common. Chlorine comes in a variety of forms and varies widely in pH. For example, most tableted forms of chlorine have a very low pH and will tend to lower pH over time, while liquid chlorine is very high in pH and will tend to raise pH values. This will be covered in more depth in the Biological section of this book. Changes in pH due to sanitizers or other factors can be minimized and controlled by the proper maintenance of the next chemical factor, total alkalinity.

II. TOTAL ALKALINITY

Total alkalinity refers to the ability of the pool water to resist a change in pH. The key purpose total alkalinity serves is to help manage or control the pH in the pool. It does this by acting as a buffer so that when materials are added to a pool that would cause the pH to go up or down, these changes are controlled and do not result in severe changes to pool water balance.

When a substance is added to pool water that could effect the pH, total alkalinity will react to neutralize it and help keep the pH in the desired range. Total alkalinity does not determine what the pH will be, but rather acts to help keep the pH in the range desired.

Total alkalinity is measured in parts per million (ppm) using a total alkalinity test kit. Total alkalinity is best kept in the range of 80-120 ppm.



When the value is less than 80 ppm, the water can become aggressive and the pH can swing easily upward and downward and back again. If the value is higher than 120 ppm, the water can become cloudy and scale forming and the pH will tend to drift upward.

In adjusting total alkalinity downward, the same acids used to lower pH are employed. When reducing total alkalinity, it is best to add small amounts of acid, either liquid or dry, over a period of several days as opposed to making large adjustments rapidly. Each time the acid is added the pH will drop initially and then the total alkalinity will neutralize it. This results in the pH returning to the previous level and the total alkalinity value will drop. Simply repeat the process daily until the desired level is reached. Adding too much acid at once may result in lowering the pH so severely that corrosion of pool surfaces and equipment may result and the existing total alkalinity may not be sufficient to raise the pH back to the normal level. When raising total alkalinity, sodium bicarbonate is the chemical of choice and the required amount can be added all at once. For more information on how to adjust total alkalinity, consult Section II – Pool Care Guidelines, Formulas and Calculations.

It is possible in freshly filled pools to find that both total alkalinity and pH need to be adjusted. It is recommended that you adjust the total alkalinity before the pH. However, in rare circumstances, you may have a condition where one factor is high and the other very low. In such a situation, you may consider first adjusting whichever factor is lower. If you find widely varying values for both pH and total alkalinity in a freshly filled pool, it may be worthwhile to wait about 24 hours before making any adjustments. This wait will generally result in some natural balancing of the water without added chemicals and is sometimes referred to as allowing the water to come into equilibrium. If additional adjustment is still needed, it will require far less time or chemical. In all cases, never add acid to the pool water if the pH is less than 7.2, even if the total alkalinity is high. Instead, wait for the pH to rise first before proceeding. If the pH does not come up by itself after a day or two, you will need to add some pH Up before proceeding.

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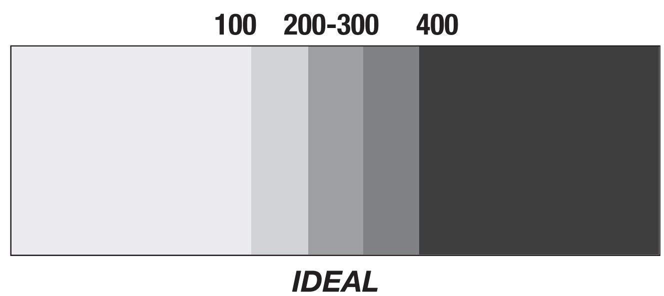
III. CALCIUM HARDNESS

The sum of all the calcium dissolved in water is referred to as the calcium hardness. Years ago, water with high levels of calcium was described as being hard to wash in. This is because water with high calcium levels does not clean clothes as well as water of a lower hardness. The term hardness is now used only to refer to the level of calcium. The term soft water refers to water with lesser or no levels of calcium.

Calcium is important since very high levels can be unstable and become even more unstable if the pH or the total alkalinity rise above the normal levels. These imbalances can result in cloudy water and/or scale. In addition, calcium does not like warm water. As water temperature rises, calcium becomes more likely to precipitate out of solution. Calcium is actually more soluble in cold water, which is why scaling of heater equipment is so common (picture the inside of a tea kettle).

With all of the difficulties calcium can cause, it would seem logical to use soft water in filling a pool. However, this is not the case. While high calcium levels can cause problems with cloudy water and scale, soft or low-calcium water is also of concern. Such water is aggressive and will actually remove calcium from plaster in order to satisfy its need for the mineral. If the pool is vinyl or fiberglass, the low calcium water will actually attack metal fittings and heat exchangers resulting in destruction of the fittings or pinhole leaks in the heater. When such corrosion occurs, it is also common for stains to appear on pool surfaces.

Calcium content is best in the range of 100-400 ppm, but higher levels can be tolerated when properly managed. Unlike pH or total alkalinity, both of which can be raised or lowered with reasonable ease, calcium levels can not. Adding calcium chloride (hardness increaser) to the water easily raises calcium levels. Conversely, there is no simple chemical addition that can be made that will reduce calcium hardness. The only way to reduce calcium hardness levels in pool water is through dilution with water of a lesser hardness.



Over time, calcium hardness will naturally increase in pool water due to evaporation and possibly other factors unless the pool water is regularly diluted. For more information on how to calculate the amount of calcium chloride needed to raise the calcium level in pool water, consult Section II – Pool Care Guidelines, Formulas and Calculations in this manual.

While it may be difficult to reduce calcium hardness, it is possible to control it so that a potential problem such as cloudy water or scale formation is prevented. The best way to minimize the effect of high calcium levels is through the use of a sequestering agent.

A sequestering agent is a compound that, when added to water, will chemically bond with calcium and other minerals to make them, in a sense, more soluble. This means that calcium will still be present, but in a form that is less likely to cloud water or form scale if the pH or other factors get out of balance. In addition, since calcium will still be in the water, you will not have the corrosion problems you would otherwise experience with soft water. A further advantage is that elevated levels of calcium (over 400 ppm) can be tolerated without constant need for dilution. This becomes especially important when the pool is located in hard water areas or calcium-based chlorine sources are used.

IV. STAIN PRODUCING MINERALS

The use of sequestering agents becomes even more important in the control of stain producing minerals.

Problems of stain formation on pool surfaces or colored water are most often associated with the metals iron, copper or manganese. Each of these metals can enter a pool by several means and will react in very different ways. One of the most common ways these metals can enter the pool is via the fill water. Therefore, before filling a pool, always be certain to have the water tested for all three metals in addition to the other chemical parameters. In this way you will be better prepared to deal with the initial pool treatment, both water balance and stain control.

IRON

When dissolved in water, iron is colorless but will react almost instantly with chlorine or other oxidizers to produce a rusty red color in water, or worse, orange colored staining. As little as 0.1 ppm of iron is all that is needed to result in colored water and stains.

The most common source of iron in pool water is the fill water. However, a simple water test does not always alert you to the possible presence of iron in the fill water. This is because over time, municipal drinking water piping systems gradually build up sediments in the pipes. This is not normally of great concern as the water flow is generally not sufficiently strong enough or of high enough volume to stir up these sediments into the flow of water itself.

Often times when large quantities of water are drawn from municipal pipes, such as when a pool is first being filled, the heavy flow of water can cause iron-bearing sediments laying in the pipes to be stirred up, causing them to enter your pool unexpectedly. If a test for the presence of iron were conducted prior to filling the pool, it would only identify iron if it were naturally occurring in the water. Any iron that may be in the sediments would likely be missed because the small amount of water drawn for the water sample would not be sufficient to stir up the sediments. Thus, the iron would remain in the pipes and not be detected until it was too late. The result could be a heavily stained pool that would then need to be emptied, cleaned or acid washed and refilled.

COPPER

A common cause of green water and stains ranging in color from blue-green to black is copper. Copper sources are more varied than iron. Copper can enter the pool water from corrosion or galvanic activity in copper heaters, from

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copper-based algaecides and from the source water. Copper problems are often indicated by pool water with a true clear green color, whereas green water caused by algae would be green and cloudy. Copper, not chlorine, is also the responsible agent when hair or fingernails turn green.

Corrosion of gas or oil-fueled heaters that have copper coils results in copper entering the water flow, which, in turn, can lead to green water or stains. This type of corrosion is most commonly due to a chemical imbalance in the water such as low pH, low total alkalinity or low calcium hardness or a combination of these factors. A galvanic action can take place in heaters where the copper metal of the heater coil comes in contact with a different metal such as iron. At points where these two dissimilar metals are in direct contact, both metals can break down and find their way into the water. This particular problem is best solved by use of a "di-electric" coupling. This is typically a pipefitting made from a ceramic or similar inert material that is placed between the two metal components.

Copper algaecides are also frequently implicated in causing stains in pools. In some cases, the copper algaecide may be responsible because the chemical complexing agents in the product used to keep the copper in solution were of lesser quality and thus allowed the copper to prematurely precipitate. However, a more common cause is likely how the product was applied to the pool in the first place. Copper algaecides come in several types and some are more prone to staining than others. However, copper algaecides are usually very concentrated, requiring only a very few ounces to be applied for each 10,000 gallons of pool water. Often times, label directions are not followed and a significant overdose occurs. In these cases, the chance of stains increases dramatically. That is why it is important to follow the label directions.

Copper can also come from the source water and will either be present as a normal component of the water or on a periodic basis. Many municipal water systems rely upon reservoirs for their water supply. These reservoirs frequently suffer from algae outbreaks and the algae is treated with copper. The copper level is often as much as 1.0 ppm, and if you fill or add water to your pool with this water, it will be green and could result in staining.

MANGANESE

Manganese is the final metal that can lead to problems and will color the water from pink to deep purple depending on the level present. Manganese only enters the pool from the source water either through natural occurrence or after being intentionally added by a water treatment plant in the form of potassium permanganate. The latter causes problems when it is inadvertently overdosed and then arrives at the pool when filling or adding water. Again, the biggest problem is that you simply do not know when the water may contain manganese.

The important thing to understand is that all three metals can easily be kept from causing problems with the regular use of a sequestering agent. As with calcium, the sequestering agent will chemically combine with the metals in the water and keep them from precipitating out of the water to cause staining. The best time to use a sequestering agent is when the pool is being filled for the first time, and thereafter as part of a regular preventive maintenance program. In this way, any metals that may be present in the fill water will be tied up or inactivated before they can cause a problem. Also, any metals that may find their way into the pool, either when water is added or from corrosive actions in the pool, will be prevented from causing staining. In other words, by adding the sequestering agent as part of the regular maintenance program, the pool will be protected from stains even when you did not expect metals to be present. It is far easier to prevent staining caused by metals than to remove the stains once they have formed.

V. TOTAL DISSOLVED SOLIDS

Total dissolved solids (TDS) are normally the least worrisome factor. TDS is the sum of all materials dissolved in the water and normally runs in the range of 250 ppm and higher.

There is much discussion over what levels are considered too high, but there is no real lower limit. TDS is comprised of many different chemical compounds, which means that the issue of how much is too much actually depends more on what they consist of than how much there is. For example, sodium chloride or ordinary salt is extremely soluble and is therefore unlikely to cause a problem, whereas, as we have seen, calcium compounds can be a problem even at fairly low levels. In general, when the TDS exceeds approximately 1500 ppm, problems may begin to occur.

It must be pointed out that pools whose sanitizing systems are based on chlorine or bromine generation equipment (salt generators) will likely have much higher TDS levels. These pools actually have salt in one form or another added to the pool. The salt used is highly soluble and does not cause the type of problems normally associated with high TDS, but never the less, it does add to the TDS level in the pool. When testing water in this type of pool for TDS, the salt intentionally added to the pool needs be taken into account.

At elevated levels, TDS can lead to cloudy or hazy water, difficulty in maintaining water balance, reduction in sanitizer activity and foaming. Unfortunately, the only way to reduce TDS is to drain a portion of the water and replace it with fresh water. Sequestering agents do not help when high TDS levels are causing cloudy water.

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BIOLOGICAL FACTORS:

Sanitization, shock oxidation treatment and **algae control** are the key elements in maintaining clean water. The previous two chapters dealt with keeping the water clear while here we will address how to keep it clean.

I. SANITIZATION

The process of controlling bacteria in the water is known as sanitization. Sanitizaion is not to be confused with the control of algae in the pool water, as algaecides are best used for that purpose. While a wide variety of methods for sanitizing pools are available, the two most common methods are chlorine and bromine. Other processes have also gained more attention, including PHMB (biguanide), ozone and ionizers. Each has its strengths and weaknesses.

CHLORINE

The most widely used sanitizer for pool sanitization is chlorine, and it is available in a number of forms. The following table lists the most commonly used forms of chlorine and some of their characteristics:

Sodium Hypochlorite (liquid bleach, liquid chlorine)	Liquid	10-12%	13-14
Dichlor (granular stabilized chlorine)	Granular	56-62%	6-7
Trichlor (tableted stabilized chlorine)	Tablets, Pucks & Sticks	90%	2-3
Calcium Hypochlorite (granular chlorine, unstabilized)	Granular	47-75%	11-13

Regardless of which form of chlorine is used, all produce the same active sanitizer when added to water. Once the chlorine has been added to the water, it can react with contaminants and then take several different forms, not all of which are desirable.

Free Chlorine

This is the most desirable form and is the form responsible for the actual sanitization activity in the water. It is measured using a free chlorine test kit and its level is critical in the pool. If this form is not present, little or no sanitizing can take place. Free chlorine is actually composed of two types of compounds: HOCl (hypochlorous acid) and OCl^- (hypochlorite ion). This is important because they exist together in a condition or state known as equilibrium. This means that together they make up 100% of the free chlorine content, but that content consists of some of each. For example, if 25% of the free chlorine is HOCl, then the OCl^- level will be the other 75%. It is important to note that only the HOCl component is effective as a sanitizer. Therefore, it seems logical that we would want as much of the free chlorine as possible made up of the HOCl. However, the level of HOCl and OCl^- present is dependent upon the pH. This is one of the critical reasons that the proper pH level in pool water is so important. As the pH goes up or down, the relative amount of HOCl vs. OCl^- also increases or decreases. The following chart shows how much of each of these two compounds are present at different pH levels.

pH	%HOCl	% of OCl^-
6.0	97	3
7.0	75	25
7.5	50	50
8.0	23	77
9.0	3	97

As the chart shows, at pH 7.5 only about half of the free chlorine exists in the desirable form of HOCl. The level of HOCl will increase as the pH goes down and it must also be pointed out that as the pH decreases, so does the stability of the chlorine. As pH rises, the stability of the free chlorine will increase, but its activity as a sanitizer diminishes. In order to get the most effective and economic benefit of chlorine, keep it in the desirable pH range of 7.2-7.8. Lower pH will be detrimental to pool surfaces and equipment, while higher levels will render chlorine ineffective as a sanitizer.

Combined Chlorine

Free chlorine is highly reactive and once added to water, quickly attacks bacteria as well as bather and other wastes. When this occurs, the chlorine is no longer considered free chlorine but rather its form has changed and is now referred to as combined chlorine. Bather and other wastes are largely made up of ammonia and nitrogen compounds. For this reason, combined chlorine is also referred to as chloramine for the nitrogen portion of the compound. Combined chlorine is very stable, but has little or no sanitizing ability. Not only is combined chlorine a very poor sanitizer, it is the agent responsible for eye burn and skin irritation and results in the unpleasant chlorine odor often referred to as a pool with "too much chlorine". It is therefore critical for bather health and comfort that combined chlorine be controlled and kept to a minimum. It is preferable that combined chlorine levels are kept to a maximum of 0.2 ppm.

Total Chlorine

This is the sum of the free chlorine and combined chlorine levels. Total chlorine can be measured using most test kits and some test strips. To determine the combined chlorine level, first measure the free chlorine level and then the total chlorine level and then subtract the free chlorine reading from the total reading. The difference in values is the combined chlorine level.

BROMINE

Chlorine and bromine are both members of the same chemical family known as halogens. While not as popular as chlorine, bromine has gained wide acceptance as a sanitizer, especially in hot tubs where the hot turbulent water tends to increase the amount of wastes in the water. The heavy waste accumulates and then places a stress on chlorine resulting in odors and irritation due to the buildup of combined chlorine. Bromine does not suffer from this problem.

Bromine is available in three basic forms: tablets, sticks and caplets or as a two

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product system. When added to water, bromine forms hypobromous acid (HOBr) similar to the hypochlorous acid formed by chlorine. However, unlike chlorine, the amount of hypobromous acid is less dependent on pH. Additionally, the combined bromine that forms when the HOBr combines with wastes in the water does not diminish bromine effectiveness like it would with chlorine. A further advantage is found in the resulting compounds, known as bromamines, which do not cause eye and skin irritation or foul odors. For this reason, it is not necessary to test for both free and combined bromine. Only a test for total bromine is needed.

Bromine tablets, sticks or caplets are usually applied through some type of feeder device either in-line or, in some cases, as a floater-type feeder. The two-product system relies upon the addition of small amounts of an inert sodium bromide salt, which by itself does little. The water is then treated with an oxidizer specially suited for this purpose, or with chlorine. The oxidizer or chlorine acts to convert the sodium bromide into free bromine. When chlorine is used this way, it reacts only to make bromine and does not act as a sanitizer itself.

BIGUANIDE (PHMB)

Another sanitizer for pools is biguanide, or PHMB. This compound has come to be known as a "non-chlorine" sanitizer, but perhaps would be more accurately called "non-halogen" since it does not rely on either bromine or chlorine. The PHMB system has created interest because it is said to be free of chlorine odors and irritation. Many people like the idea of getting away from the use of traditional sanitizers. While PHMB can be effective in controlling most microorganisms, the system is different from traditional sanitizers and has some drawbacks. For example, the system does not tolerate the addition of chlorine or bromine, and if added to a biguanide pool, these products can cause the formation of gummy deposits on surfaces and pipes. Since most source water contains chlorine as a treatment chemical, small amounts of the gummy deposits can form over time. On the positive side, the product is stable in the water and needs to be added only in top off doses every week or two and does not require the constant testing of levels as do chlorine or bromine. Absence of chlorine odors, reduced skin irritation and ease of maintenance are also claimed.

OZONE

While ozone has gained wide acceptance and use in hot tubs, it is now gaining more use in pools as well. Chemically, ozone is a highly reactive oxidizer and is the most effective of all oxidizers in its ability to kill the microorganisms it comes in contact with. Because it is so reactive, it must be produced on-site by specialized equipment or UV light. In nature, ozone is produced by electrical discharge such as occurs in lightning. While effective, ozone is not very stable because it has a very short life in the water, which means that only water and contaminants actually in contact with ozone at any given moment can be considered sanitary. Therefore, ozone most be supported by the use of a backup sanitizer – usually chlorine or bromine. The advantage ozone holds is that it will reduce the levels of chlorine or bromine normally needed to operate a given pool.

MINERAL TREATMENT

Minerals such as silver and copper have long been recognized for their ability to keep water fresh for drinking. The pioneers used to place copper and silver coins in their barrels of drinking water as they traveled west. Over the past 20 years or so these minerals have been used to treat pool water. The minerals copper and silver have received most of the attention and more recently zinc has gained interest as well. The minerals are produced by electrolytic means or by controlled erosion. In either case, low doses are continuously fed into the water and work to suppress bacteria.

The systems used do not control organic waste and therefore these must still be managed through oxidation. In addition, the levels added to water do not assure control of all bacteria or algae and it is highly desirable to supplement these minerals with low levels of chlorine or bromine. The combination of the halogens and minerals results in a true synergistic ability to control undesirable organisms and wastes at low levels.

II. SHOCK/OXIDATION TREATMENT

Regardless of which sanitization system is used, the control of bather and other wastes is critical. For example, one active swimmer produces two pints of perspiration per hour in a pool. Perspiration contains a wide range of organic and inorganic contaminants and these will accumulate and combine with chlorine to form the very undesirable combined chlorine form. In bromine systems, although odors and irritation are not a problem with bromamines, the wastes themselves can build up and eventually make the water uncomfortable for bathing. The regular removal of these wastes is a must in any system.

The best way to remove these wastes is with regular oxidation. The odor that is associated with combined chlorine is often mistakenly referred to as "too much chlorine in the water," but actually indicates that there is too little. Shock oxidation treatment or super chlorination is needed to destroy these wastes. We use the phrase "shock oxidation treatment" when referring to the use of non-chlorine type shock-oxidizer. Conversely, the phrase "super chlorination" is used when referring to the use of a sudden large dose of chlorine.

In either case, the goal is to destroy and remove bather waste in addition to preventing the formation of combined chlorine or the accumulation of irritating waste products.

SUPER CHLORINATION

Super chlorination is effective in eliminating wastes or destroying combined chlorine. To achieve successful super chlorination, a single large dose of chlorine is applied to the water. Super chlorination actually works by first reacting with the organic wastes in the water to form more combined chlorine. Once a sufficient level of chlorine has been added, all of the organics will have been reacted with (oxidized), and only then will the combined chlorine break down leaving free chlorine. Typically, the amount of chlorine required is ten times the level of combined chlorine in the water. For example, if the chlorine test shows a level of 1.2 ppm of combined chlorine you will need to add 12 ppm of additional chlorine in order to destroy all of the combined chlorine. In addition, while effective, super

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chlorination also has a number of drawbacks, which include:

- requires a large amount of chlorine
- can damage liners and swimsuits
- upsets water balance
- difficult to determine proper dosage
- cannot swim until free chlorine level drops to 1-4 ppm

When using chlorine to destroy combined chlorine, failure to use a sufficient quantity will actually result in more combined chlorine, odor and irritation rather than less. The use of too much chlorine can cause the types of problems listed above.

SHOCK OXIDATION TREATMENT

Shock oxidation treatment is a phrase commonly used when referring to the use of a product that does not contain chlorine to eliminate wastes in the water. Instead, it uses a unique oxidizer to control wastes. Most commonly referred to as "non-chlorine" shock, oxidizer it does not use chlorine to destroy the wastes, as the name implies. Non-chlorine shock uses an oxidizer that will directly oxidize the waste itself, whereas chlorine used in super chlorination works by first changing the waste into combined chlorine before final breakdown. Since non-chlorine shock oxidizer does not require chlorine, it can be used to destroy waste products before they have a chance to form combined chlorine, and it offers several significant advantages including:

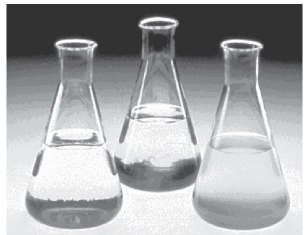
- does not require excessive chlorine use
- will not harm liners or suits
- will not upset water balance
- easy to determine needed dosages
- can swim as soon as 15 minutes after treatment

Shock oxidation treatment or super chlorination should be administered at the start of the pool season. Frequency of application thereafter depends on several factors including: bather load, heavy rains or the presence of combined chlorine. Most residential pools should be shocked every week or two, while commercial pools should be treated at least weekly and more often if there is a heavy bather load or if the combined chlorine level is greater than 0.2 ppm.

Heavy rainfall also places a large amount of debris or organic material into pool water that can lead to combined chlorine or even algae growth. Shock oxidation treatment following a heavy rain will help in avoiding these problems.

The best way to handle problems, including combined chlorine, is to prevent them from occurring. Non-chlorine shock oxidizers prevent the problem before it occurs. Super chlorination is most often used after the problems with combined chlorine become obvious.

III. ALGAE CONTROL



The final biological factor that must be considered is algae control. Algae growth is perhaps the most obvious sign of something gone wrong in pool maintenance. Proper maintenance will not only keep your water looking great, but also allow for easy prevention of algae growth.

There are two basic groups of algae:

1. The free-floating types include the green and mustard varieties. They tend to be found throughout the water. While they may cling or settle on surfaces such as walls and floors, they are not usually affixed to them and are easily brushed off. They tend to color a water body cloudy green or yellow.

2. Black algae is the common name or term given to the dark blue-green algae found growing on pool surfaces. Black algae growth in localized areas such as along one wall, in the deep end, in a corner or around obstacles such as steps indicates an area of poor circulation.

The growth of both types of algae can be easily prevented by using a quality algaecide as part of a regular maintenance program, and by proper circulation. It takes far less algaecide to prevent algae growth from getting started than it will to cure it once it has occurred.

The regular use of algaecide is also recommended to prevent problems, should a failure of the sanitization program occur. Due to the volatile nature of chlorine or bromine, these residuals can often be lost very quickly in pools due to equipment or operator error or by heavy rainfall or bather waste demand. If this occurs without an algaecide present, the rapid growth of algae can occur in a few hours. However, if an algaecide is present, it will act as algae growth prevention until the sanitizer system is functioning normally.

In spite of our best efforts, algae problems do occur and require some consideration for proper treatment. When an algaecide becomes necessary, the following factors need to be considered before treatment:

- The number of algae present. It is critical that sufficient algaecide is added to treat all of the algae at one time. The use of only some of the needed algaecide will not kill some of the algae. It is important to follow the directions for use on the package.
- Age of the algae. The older algae becomes, the more difficult it is to control. Treat the problem as soon as it is noticed.
- Sunlight and water temperature. It is best to treat when algae are actively growing. Sunny days and a water temperature of 60°F or higher will be helpful.
- Type of algae. Different types of algae require different types of treatment.

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GREEN ALGAE

The most common algae associated with swimming pools is green algae. It is very opportunistic, meaning it will take advantage of any failure in the normal sanitizing program and quickly infest a pool. One will see green algae problems frequently appear overnight following heavy rainstorms. This is because rainstorms, especially those with lightning, actually provide food for the algae in the form of nitrogen. The nitrogen not only feeds the algae but also destroys chlorine residuals by forming combined chlorine. Green algae must not be mistaken for problems with copper content in the water. If high levels of copper are present, the water will become a clear green, whereas green algae will cause a cloudy green appearance.

The best way to treat for green algae is to prevent it in the first place. Use an algaecide regularly as part of a normal maintenance program. This will prevent algae from growing, even if a failure in the sanitizing system was to occur. It is always easier and more effective to prevent the algae problem than to try and eliminate it once it occurs. When it does occur, treat it promptly. The longer the wait before treatment, the more difficult and costly the result. Select an algaecide that will both treat the existing algae and prevent renewed growth. Follow the label directions and maintain circulation during treatment.

YELLOW OR MUSTARD ALGAE

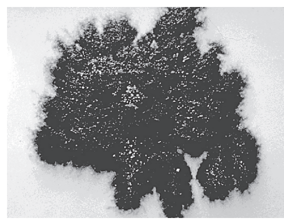
The yellow or mustard algae is very similar in form to the green algae, but is much slower growing and is deficient in chlorophyll (green pigment) which accounts for its yellow color. Because yellow algae grow very slowly, it is also very difficult to destroy. By the time you see it growing in your pool, it has likely been there as long as several weeks. Additionally, since yellow algae is low in chlorophyll which is light-loving, the algae live and even grow in dark areas of the pool such as plumbing and filters. This only compounds the difficulty of control. Care in selection of a proper algaecide is most important. Be certain to select a product made for the control of this unique form of algae. Copper-based algaecides seem particularly well suited for controlling yellow algae, but others, including recently developed synergistically blended products, are also effective. One word of caution: it is not unusual to need to treat yellow algae more than once to bring it fully under control. This again points out the value of preventing the growth in the first place.

BLACK ALGAE

Frequently considered the most difficult algae to control is the one we commonly refer to as "black algae". However, it is also likely the easiest to prevent. Black algae typically gain a foothold in areas of the pool that suffer from poor circulation. Areas such as corners or in certain areas of the deep end are often identified as places where black algae continue to show up in a particular pool and are then nearly impossible to eliminate. Most often, these areas suffer from inadequate circulation and thus little or no fresh water, sanitizer or algaecide gets to the area with any regularity. One of the best ways to prevent black algae growth or eliminate it once it surfaces, is to correct the circulation problem(s) first.

Once it begins forming, black algae develops specialized cells that lock it deep in the pores of pool surfaces. In order to effectively control it, all of its cells including those deep in the surface, must be killed. It is all but impossible for chlorine alone to get this deep into the pores of the pool's surfaces. In addition to the attaching or locking mechanism of black algae, the growing colony also produces a defense mechanism. Outer layers of the colony produce a waxy coat that prevents chlorine or algaecides from penetrating into the colony and killing it. Therefore, the algaecide used should contain a "penetrating" agent. This agent will actually work to help the algaecide penetrate into the pores of the pool surface and cut through the waxy coat with a special wetting action that chlorine does not have.

The following steps will help in bringing black algae under control:



1. Correct any problems with the circulation pattern in the pool.
2. Brush the colonies as this will break through the waxy coating protecting the colony.
3. Add an algaecide intended for use on black algae.
4. Brush the colony daily thereafter, if possible, as this will remove any dead cells from the surface exposing the living cells underneath for exposure to the algaecide.

Following these simple procedures when treating black algae will not only help insure its successful removal, but reduce the likelihood of its return as well.

SUMMARY

Pool maintenance is not simply about adding chemicals, filtering water and preventing algae growth. Maintenance is comprised of a wide range of factors all working on an interrelated basis. To be successful, it is necessary that each component is understood and managed as it relates to the others. Pool care is not difficult so long as it is approached as problem prevention as a matter of practice, and not merely waiting to solve problems when they occur. Of course, when problems develop they need be resolved, but the point is that if management consists solely of reacting to problems, we are simply not doing our jobs in keeping swimming enjoyable.

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FORMULAS AND CALCULATIONS

HOW TO CALCULATE POOL SIZE

CIRCULAR OR OVAL POOL

Multiply ½ the length (or diameter) by ½ the width (or diameter) of the pool. This gives the surface area.
Multiply that number by 3.14 and then multiply by the average depth of the pool.
To determine volume in gallons, multiply the final number by 7.5.

Example:
30 ft by 20 ft pool with 6 ft deep end and 3 ft shallow end
15 x 10 = 150, 150 x 3.14 = 471 square feet
471 x 4.5 (average depth) = 2,119.5
2,119.5 x 7.5 = 15,896 gal

SQUARE OR RECTANGULAR POOL

Multiply the length by the width by the average depth. Then multiply by 7.5 to determine size in gallons.

Example:
16 ft by 32 ft rectangular pool, 5 ft average depth
16 x 32 x 5 x 7.5 = 19,200 gal

HOW TO ADJUST TOTAL ALKALINITY

TO INCREASE TOTAL ALKALINITY:

1.5 pounds of Alkalinity Increaser or Sodium Bicarbonate will increase the total alkalinity of 10,000 gallons of pool water by 10 ppm.

TO DECREASE TOTAL ALKALINITY:

Add small amounts of liquid or dry acid once each day until desired level is reached. In general about 2 pounds of dry acid will reduce total alkalinity of 10,000 gallons of pool water by 10 ppm. For minor adjustments, do not add more than one pound of dry or one pint of liquid to 10,000 gallons of water per day.
DO NOT ADD ANY ACID IF pH IS LESS THAN 7.2.

HOW TO INCREASE CALCIUM HARDNESS

To increase calcium hardness, add calcium chloride.
One pound of calcium chloride will increase the calcium hardness of 10,000 gallons of water by 10 ppm.

PROPER POOL MAINTENANCE

Success in the care and management of a pool is best demonstrated by the overall appearance of the water and the surrounding pool area. How good a pool looks has as much to do with how well it is started up or closed at season end as it does with how it is run during the season. Pool maintenance is not difficult. It is best to follow a regular maintenance program that results in the prevention of problems before they begin. This section will address some basic guidelines on how to start up a pool initially or in the spring, maintain it during the season, and close it for the off season. Before beginning, it is best to understand some concepts in the handling, application and safe use of pool treatment products.

HANDLING POOL CHEMICALS

1. Always read and familiarize yourself with label directions prior to adding or using a product.
2. Always use the correct dosage as instructed.
3. Never add chemicals through the skimmer system unless specifically directed to do so.
4. Never mix one chemical with another chemical prior to adding to the pool water.
5. Store chemicals in a cool and dry location out of direct sunlight.

POOL START UP PROCEDURE

The following procedure should be used whenever a pool is being filled for the first time, refilled following maintenance or other major repair or when restarting the pool for the swimming season.

1. Before first filling a pool or adding substantial amounts of fresh water to the pool, either test the water using a good quality test kit or have it tested for pH, total alkalinity, calcium hardness and stain producing metals. This will tell you what type of treatment will likely be required once the pool is full and allow treatment measures to be taken that will prevent problems from the water source.
2. In cases where the pool is being reopened and was covered all winter, remove the cover carefully so as to avoid having any leaves or other debris fall into the pool. Sweep up and remove as much material as possible that may have accumulated in the pool during the off season.
3. In cases where the pool is being completely filled be certain to add a good sequestering agent as soon as the filling process begins. If the pool is already full, add the sequestering agent before any other steps are followed. This will tie up and inactivate any stain-producing metals that may be in the fill or pool water. This should be done even if the water analysis did not show the presence of these metals in the water sample. Note: If the pool construction happens to be black plaster, the sequestering agent should not be added until the pool is completely full.
4. Add a clarifier to the water. The clarifier will help the filter remove the very tiny particles that enter the pool in the filling process or that may remain following construction and installation.
5. Start the pump and filtration equipment and allow the water to circulate for 24 hours, if practical. This will assure that the sequestering agent and clarifier have been completely mixed in the water thus avoiding stain formation, cloudy or colored water.

6. Shock oxidize the pool using a quality non-chlorine shock oxidizer. This will destroy organic wastes in the water and keep them from interfering with the sanitizer or acting as a food source for algae. It will also help give the water a "polished" look.
7. Again test the water and adjust if needed to balance the water. pH should be in the range of 7.2-7.8, total alkalinity between 80-120 ppm and calcium hardness between 100 and 400 ppm.
8. Begin to add your desired sanitizer to the water following the manufacturer's guidelines.
9. If using chlorine in an outdoor pool, stabilizer (cyanuric acid) should be added to help the chlorine last longer and work more economically. Consult label directions.
10. Add an algaecide. The algaecide will prevent any algae in the pool from growing even if the sanitizer used were to fail. The regular use of an algaecide will keep the pool looking clean and bright and help the sanitizer to work more efficiently.
11. Test the sanitizer residual and maintain at the recommended level.
12. The pool is now ready for use.

WEEKLY MAINTENANCE

Following a regular maintenance program not only helps to prevent problems but also keeps the water sparkling clean, clear and inviting. Following the steps detailed here will help make maintenance easy and the pool will always be ready for use.

1. Vacuum the pool to remove dirt and debris that has accumulated on the bottom. More frequent vacuuming can be beneficial but it should not be done less than once each week.
2. Check the pressure or vacuum gauges on a sand or Diatomaceous Earth filter to determine if the filter requires backwashing. Backwash following the filter manufacturer's directions. Note: Some manufacturers produce a product that helps remove deeply-set dirt during the backwash process. Such products may help in improving filter performance during the season. If the pool has a cartridge filter, the cartridge should be inspected to determine if cleaning beyond a simple rinsing is required. Regardless of filter type, if the media is unusually dirty, it should be cleaned with a quality filter cleaner made for pool filters.
3. Add water as needed. Check and adjust pH and total alkalinity. Test sanitizer residual, adjust as needed and refill feeders as required.
4. Add a sequestering agent every week. Even if metals are not detected in the water tests they can contaminate when least expected and calcium can precipitate to form scale or cloudy water. The small amount of sequestering agent used weekly will be far less costly than the expense incurred in acid washing or stain removal.
5. Add a maintenance dose of clarifier to help the filter in removing even the smallest particles that can otherwise lead to hazy water conditions.
6. Shock oxidize the water using a non-chlorine shock oxidizer. Regular shock oxidation will help prevent the formation of combined chlorine, red eyes, odors and skin irritation. The shock treatment will also help the sanitizer work better.
7. Add a maintenance dose of algaecide. The algaecide will prevent algae growth even if the sanitizer system were to fail or in the event of heavy bather loads or rainfall.
8. Add an enzyme oil and grease digester to help break up scum lines and reduce filter clogs.
9. Clean along tile lines, surrounding pool areas and patio furniture.

SALT GENERATOR POOL MAINTENANCE

Salt generator pool maintenance is little different from other chlorine treated pools. It is important to realize that the generator does not replace anything in the pool except the need to add chlorine as this is made by the generator. Following the steps detailed here will help make maintenance easy and the pool will always be ready for use.

1. Vacuum the pool to remove dirt and debris that has accumulated on the bottom. More frequent vacuuming can be beneficial but it should not be done less than once each week.
2. Check the pressure or vacuum gauges on a sand or Diatomaceous Earth filter to determine if the filter requires backwashing. Backwash following the filter manufacturer's directions. Note: Some manufacturers produce a product that helps remove deeply-set dirt during the backwash process. Such products may help in improving filter performance during the season. If the pool has a cartridge filter, the cartridge should be inspected to determine if a cleaning beyond simple rinsing is required. Regardless of filter type, if the media is unusually dirty, it should be cleaned with a quality filter cleaner made for pool filters.
3. Add water as needed. Check and adjust pH and total alkalinity. Test sanitizer residual and adjust the generator as needed to maintain sufficient chlorine level.
   Monthly: use a salt test kit to determine salt level and adjust if needed. Salt levels will not change rapidly and may only need more salt once or twice per season and in many cases not at all.
4. Add a sequestering agent every week. Even if metals are not detected in the water tests, they can contaminate when least expected and calcium can precipitate to form scale or cloudy water. The small amount of sequestering agent used weekly will be far less costly than the expense incurred in acid washing or stain removal. This will also help reduce scale buildup on the salt generator cell.
5. Add a cell protection chemical that helps reduce oil and grease buildup and protects and extends the life of the cell by reducing other scaling agents that are not inhibited with a standard sequestering agent.
6. Add a maintenance dose of clarifier to help the filter in removing even the smallest particles that can otherwise lead to hazy water conditions.
7. Shock oxidize the water using a non-chlorine shock oxidizer. Regular shock oxidation will help prevent the formation of combined chlorine, red eyes, odors and skin irritation. The shock treatment will also help the chlorine work better.
8. Add a maintenance dose of algaecide. The algaecide will prevent algae growth even if the generator system were to fail or in the event of heavy bather loads or rainfall.
9. Add an enzyme oil and grease digester to help break up scum lines and reduce filter fouling.
10. Clean along tile lines, surrounding pool areas and patio furniture.

WINTERIZING THE POOL

Proper closing of the pool at the conclusion of the swimming season will help assure an easy opening for the next season. If the pool is not properly treated now the water and pool surfaces will all be heavily fouled when the pool is reopened and plumbing and equipment could be damaged, thus requiring significant time and expense to get the pool back into operation.

1. Brush the walls and floor and vacuum up all loose debris from the pool bottom.
2. Clean the filter or cartridges using a good quality pool filter cleaner. It will be far easier to clean the filter now than in the spring and will assure good filtration on start up.
3. If the water level is to be lowered for the winter, do so now and then proceed to step 4.
4. Completely drain all water from pipes, pumps, heaters, filters and other pool equipment to prevent damage due to water freezing. Use antifreeze especially made for pool use, if necessary.
5. Shock oxidize with a non-chlorine shock oxidizer. This will eliminate organic contaminants that would otherwise help support algae growth.
6. Add an algaecide to eliminate algae growth throughout the winter.
7. Add a sequestering agent to prevent any calcium precipitation or stains due to metals. The sequestering agent will also help protect any metal components and equipment.

Note: In mild climates where the pool is left full and uncovered for the winter, it is suggested that the filtration system continue to operate and the sanitizer, algaecide and sequestering agent be added regularly in addition to following steps 1 and 2 above.

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