New Zealand Pool Industrey Association Inc, PO Box 170769 Greenlane 1546 – email executive@poolguild.org.nz

PAPER 9 INFORMATION PAGE **Your Name** ______________________

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POOL WATER SANITISATION

NAME	ADVANTAGES	DISADVANTAGES
Chlorine (Gas)	Strong (100% Av. Chlorine) Does not alter hardness fully Soluble	Dangerous for amateurs Must be dosed together with Soda Ash/Bicarbonate of Soda to prevent acid build-up (i.e. low pH) Strict regulations cover storage and use
Sodium Hypochlorite (Liquid pool chlorine)	Not a fire risk Easy to handle Easy to Automate Does not alter hardness Fully soluble	Lower strength (12 1/2% Available chlorine loses strength slowly (quickly if incorrectly stored or mis-handled).
Calcium Hypochlorite (Granular Pool Chlorine)	Strong (65% Av. Chlorine) Negligible loss of strength Strength on storage only small effect on pH	Fire risk if incorrectly stored or mishandled Some insoluble matter raises hardness
Sodium Dichloroisocyanurate (Stabilised Chlorine)	Strong (60% Av. Chlorine) Negligible loss of strength Strength on storage Little effect on pH Fully soluble Does not alter hardness	Fire risk if incorrectly stored or mishandled. UV stabiliser slows the 'killing speed" hence may not be possible to use it continuously
Trichloroisocyanuric Acid (Trichlor Tablets)	Strong (85% Av Chlorine) Negligible loss of strength on storage Fully soluble Does not alter hardness Contains UV stabilizer	Fire risk if incorrectly stored or mishandled UV stabiliser slows the "killing speed" hence may not be possible to use it continuously - Lowers pH
Electrolytic Chlorinators ("Salt Chlorinators")	Safe Semi-Automatic	May be under/over dosing possibility of strong current current corrosion
Brominated Hydantoin (Bromine Sticks)	Strong Fully soluble Does not alter hardness More stable in hot water conditions.	Cannot be UV stabilised Costly
Iodine Compounds	Strong Fully soluble Does not alter hardness	Cannot be Uv stabilised Costly Stains if in excess

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NAME	ADVANTAGES	DISADVANTAGES
Poly (Hexamethylene Biguanide) Hydrochloride - Hydrogen Peroxide	Odourless, Tasteless Long lasting effect Stable to UV light Safe to handle (except hydrogen peroxide) Should not aid "Black Stain" formation in Fibreglass pools Fully soluble Does not alter hardness	Incompatible with Chlorine Requires good filtration systems, well maintained Does not bleach out leaf stains
Silver/Copper Compounds	Stable Safe	Slow in action - must usually be used in conjunction with chlorine Water chemistry must be closely controlled to prevent staining problems.
OZONE	Strong sanitizer Does not alter hardness Costly	Harmful to people and residues must be removed before returning to pool
UV Radiation	Fair sanitizer Does not effect Water chemistry	Effectiveness quickly Reduces with distance Harmful to eyes of swimmers

CHLORINE-BASED SANITIZERS
Technical formulas (– you are not expected to memorise these formulae, but see if you can follow them)

Chlorine gas is made from salt solution by electrolysis. By-products from the production are caustic soda and hydrogen gas. The manufacturing process can be described by the following equations:

1. 2 NaC1 + 2 H2O --> C12 + 2 NaOH +. H2+
   salt water chlorine caustic hydrogen

When chlorine gas is dissolved in water it forms hypochlorous acid and hydrochloric acid:

2. C12 + H20 --> HOCI + HC1
   hypochlorous acid

The HYPOCHLOROUS ACID formed in the reaction is the active compound in all of the chlorine-based sanitizers as hydrochloric acid has no bactericidal properties. Chlorine gas is too dangerous to handle therefore it is not sold to backyard pool owners. Instead chlorine is made safer by neutralizing it with caustic solution to form sodium hypochlorite and salt.

3. C12 + 2NaOH -->NaOC1 + NaC1 + H20

Sodium hypochlorite thus produced is the active ingredient of the liquid pool chlorine.

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When chlorine is added to lime water calcium hypochlorite and calcium chloride are produced:

4. $$2C12 + 2Ca<OH>2 \rightarrow Ca<OCl>2 + 2\,H20$$

Calcium hypochlorite is the active ingredient of granular pool chlorine.

Chlorine is also reacted with isocyanuric acid to produce the stabilized chlorines, namely sodium dichloroisocyanurate and the trichloroisocyanuric acid.

ELECTROLYTIC CHLORINE GENERATORS
The process, sometime referred to it as salt water chlorination, requires about 0.4% (4000 mg/L) salt in the pool water. The water is pumped through the cell where the electric current converts salt and water to sodium hypochlorite, sodium hydroxide and hydrogen gas. Requirements of the generators are:

a. to produce enough chlorine within 5-6 hours of operation;
b. to not generate chlorine and hydrogen when the pool pump is not operating;
c. to be installed in such a manner that the hydrogen gas cannot find its way back into the pump where it may cause an explosion;
d. high levels of calcium hardness should be avoided as this causes scale build-up on the electrodes;
e. combine with an acid feeder to prevent high pH levels which negate the sterilisation effectiveness

Before deciding on the use of salt in the pool water its corrosive effect on the pool's structure and its surrounding should be considered. This also applies to any chloride electrolysys unit i.e. magnesium chloride.

HOW CHLORINE WORKS
As indicated earlier when chlorine is dissolved in water both hypochlorous acid and hydrochloric acid are formed as indicated below:

$$C12 + H2O \rightarrow HOC + HC1$$

When calcium hypochlorite, the active ingredient of granular pool chlorine is dissolved in water that also forms hypochlorous acid as shown below:

$$Ca(OCl)2 + 2H2O \rightarrow 2HOC1 + Ca(OH)2$$

In fact all chlorinating compounds produce hypochlorous acid in pool water, which is the same active ingredient irrespective of the form in which these chemicals are sold, i.e. granules, tablets or liquid etc.

Hypochlorous acid is a powerful oxidizing agent which can destroy organic matter to produce carbondioxide and water. A simplified equation describes the reaction:

$$CH4 + 4HOC1 \rightarrow CO2 + 2H20 + 4HC1$$

As a result chlorine can destroy leaf-stain, tannins and this property is responsible for bleaching of coloured clothes.

Hypochlorous acid is an excellent sanitizer because it is a small and neutral molecule that can penetrate the cell walls of bacteria, algae and other micro-organisms. Once inside it destroys the enzymes which are essential for the metabolism of the organisms.

In addition hypochlorous acid is capable to react with or to destroy contaminates like sweat, urine, etc. These body waste products contain nitrogen and are related to ammonias or urea. Depending on the concentration of the chlorine relative to the amount of contaminates the following reactions may take place:

$$NH3 + HOC1 \rightarrow NH2C1\ \text{(monochloramine)} + H20$$
$$NH2C1 + HOC1 \rightarrow NHC12\ \text{(dichloramine)} + H20$$

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NHC12 + HOC1 --> NC13 (trichloramine) + H20

These chloramines together are called ***combined chlorine.***

Monochloramine has significantly less bactericidal activity than free chlorine (about 2,500% less!), di- and trichloramines have none. Trichloramine strongly irritates the eyes, it imparts a "chlorinous" odour and an objectionable taste to the water even at low concentrations.

Due to their undesirable side effects that chloramines should be kept to a minimum by maintaining a sufficient concentration of free chlorine in the pool water at all times and after heavy use of the pool, when the regular dose is inadaequate, they should be eliminated by superchlorination.

When chlorine is insufficient excess the chloramines are oxidized to nitrogen gas and chlorides.

Mono - and dichloramines are produced within minutes after they are introduced into the pool, however, their destruction may take hours.

Trichloramine is formed at any pH, however, it is more likely to be produced and is more stable if the water is acid. It will decay slowly at the alkaline conditions, provided that chlorine is well in excess.

There are small amounts of un-reactive chloramines which cannot be eliminated by chlorination.

CHLORINE DEMAND

This is the amount of chlorine needed in any particular pool water to destroy all of the bacteria, algae and organic matter including the combined chlorine. This amount may vary from pool to pool, depending on the swimming load and on the amount of wind-borne debris. For instance, two neighbours may each have an identical pool. One of them is exposed to the wind carrying dust, pollen and leaves into it. The area around the pool is not paved and there are several kids in the family and they use the pool constantly.

The other pool is more sheltered, it is quite free of leaves, the surround is all paved and only the middle-aged couple use it occasionally. The first pool water will have a much higher chlorine demand than the second one.

FREE OR AVAILABLE CHLORINE

Chlorine which is in the form of hypochlorous acid is referred to as FREE or AVAILABLE CHLORINE, capable of carrying out the above tasks. The free chlorine residual is the amount of free chlorine which is left AFTER THE CHORINE DEMAND HAS BEEN MET. The purpose of pool water sanitization is to maintain a sufficient amount of free chlorine in the pool in order to have a safe, pure, non-irritating water.

COMBINED CHLORINE

Chlorine in the form of chloramines is called COMBINED CHLORINE. This form of chlorine has very little sanitizing potential and it is undesirable in the pool water.

TOTAL CHLORINE

The sum of the free chlorine and the combined chlorine is the TOTAL CHLORINE. Be aware that some Reagent Test Kits will show combined chlorine readings after about one or two minutes, the INITIAL reading being the FREE CHLORINE reading. Don't be fooled by this phenomenon.

BREAK-POINT CHLORINATION

When sufficient chlorine was added to the swimming pool water after use so that all of the chloramines* were destroyed and any further addition of chlorine forms free available chylorine, BREAK-POINT CHLORINATION was achieved. The aim of the pool water chlorination is to operate beyond the break-point chlorination as long as possible between dosings.

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*Not all the chloramines can be destroyed by chlorination. The level of the unreactive chloramines can be reduced only by discharging part of the pool water and replacing it with fresh water.

METHODS OF DOSING
There are two methods of dosing: shock or intermittent dosing and continuous dosing.

SHOCK DOSING.

The daily dose of chlorine or a large part of it is added to the pool within a few minutes. Because of the relatively large amount of chlorine added over a short period localised high concentration of chlorine can occur even if the filter is operating therefore the pool should not be used during shock dosing and afterwards until sufficient time lapsed for the chlorine to be mixed with the water.

SUPERCHLORINATION

Superchlorination is a form of shock dosing of the pool water with 2-4 times the normal daily dose of chlorine. It is carried out everytime after heavy or prolonged use of the pool by bathers to destroy the contaminates and chloramines and to restore break-point chlorination in the pool water.

The solid chlorine granules may be added directly to concrete pools by scattering it over the whole surface or sparsely alongside the edges and corners, but do not follow this procedure with vinyl liner or fiberglass pools or bleaching damage may occur. Accumulation of the solids should be prevented by immediate and rapid brushing as this may cause fading or blistering of the pool's interior. Alternatively the granules may be dissolved in water and like the liquid pool chlorine, added to the pool water via the skimmer to ensure maximum dispersion while the filter is operating.

CONTINUOUS DOSING.
The daily dose by Floating devide is fed to the pool gradually during the period the filter is operating or as long as the chlorine-containing float is in the water. A Mechanical dosing system may inject a solution of chlorine into the circulating water or generate the chlorine by electrolysis in the salt-containing water. As the rate of dosing by the systems with chlorine is low the pool may be used by bathers during the process, however, floats containing chlorine compounds must be removed before people, especially children, enter into the water. Ozone generating sanitizing devices also operate as long as the filtration system and the unit is switched on.

The main dosing of the pool with chlorine is best carried out late in the day after all the swimming activities ceased. Ideally enough chlorine should be added every day so that all the combined chlorines are destroyed and break-point chlorination is achieved; i.e. all the chlorine is free available chlorine.

DOSAGE RATES
Recommendations for dosage rates are provided by the manufacturers of the chlorinating products and those should be followed. However, as the chlorine demand varies from pool to pool the adequacy of dosing should be checked regularly by testing the pool water. A general guide for dosage rates is listed in APPENDIX 1.

THE EFFECT OF pH ON CHLORINE
As we have seen previously when chlorine is dissolved in water it forms hypochlorous acid and hydrochloric acid. However, there is another reaction that takes place as the hypochlorous acid parts to form hydrogen ion and hypochlorite ion according to the equation below:

Equation 1. C12 + H20 --> HOC1 + HC1

Equation 2. H0C1 --> H + OC1

The reaction in Eq. 2 depends on the pH. Hypochlorous acid (HOC1) is about 100 times more effective as a sanitizer than the hypochlorite anion (OC1) therefore the aim of the chemical treatment is to maintain a pH which provides optimum sanitization of the water.

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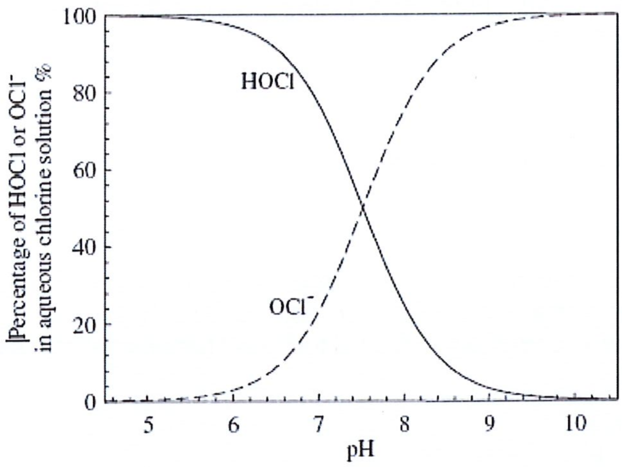
Fig. 1. Dependence of the ratio HOCl/OCl⁻ on pH ($pK_a = 7.5$).



The relative proportions of hypochlorous acid and the hypochlorite anion listed against the various pH values in the graph below:

Seen Graph this before – probably not!

Remember it!
It shows you how ineffective chlorine becomes at high pH i.e. over a pH of 8.0 the chlorine is practically useless. If you install Saline Chlorinators, the pH is almost always over 8.0 unless you use the models that include acid dosing to counter the alkalinity!

Also note that chlorine is most effective at pH 5.5 – the pH of human tears, which is why they 'sting', but this water is too acidic for people and will also 'sting' eyes, and damage pool equipment.

COMMENTS.

1. Although chlorine is ***more effective*** at pH values less than 7 the water is too corrosive for use as a swimming pool.

2. When the higher pH values are necessary for the chemical balancing of the water the minimum chlorine concentration should be increased, thus if the minimum chlorine is 1 mg/L at pH 7.1, then it should be 3 mg/L at pH 8.0.

3. Chlorine is NOT LOST due to this dissociation as the equilibrium will be restored immediately as the hypochlorous acid is used up. However, its potential of killing certain micro-organisms, in particular the amoeba, is weakened.

EFFECT OF SUNLIGHT ON CHLORINE
Ultra-violet rays of the sun destroy chlorine at such a rate that the concentration of chlorine is being reduced to half of its strength every 30 minutes or it is destroyed completely within less than 4 hours.

This is not only wasteful; also it leaves the swimmers without any protection against infection by bacteria. To overcome this problem the chemical isocyanuric acid, also called the stabiliser, is added in small amounts to the pool water. The effect of the "stabilizer" at varying concentration on the chlorine content of the pool water is shown on the graph below.

There is a dramatic improvement in the preservation of the chlorine when 25-50 mg/L of the "stabiliser" is used.

However, concentrations of the "stabiliser" over 50 mg/L did not produce any significant improvements and they are not recommended. The concentration of the "stabiliser" in excess of 100 mg/L should be avoided as this will adversely effect the sanitizing potential of chlorine.

"Stabilisers" are not recommended for indoor pools or spas.

Effect of Cyanuric Acid on the Stability of Hypochlorite Exposed to Sunlight. *

(Basis: Chlorine-demand free water, pH = 7.0, exposed 7/26 to sunlight sunny day, air and solution temperature 30-35^{0}C, original OC1 - = 2-3 ppm.) * Data based upon samples tested in the lab and are not guaranteed for all samples.

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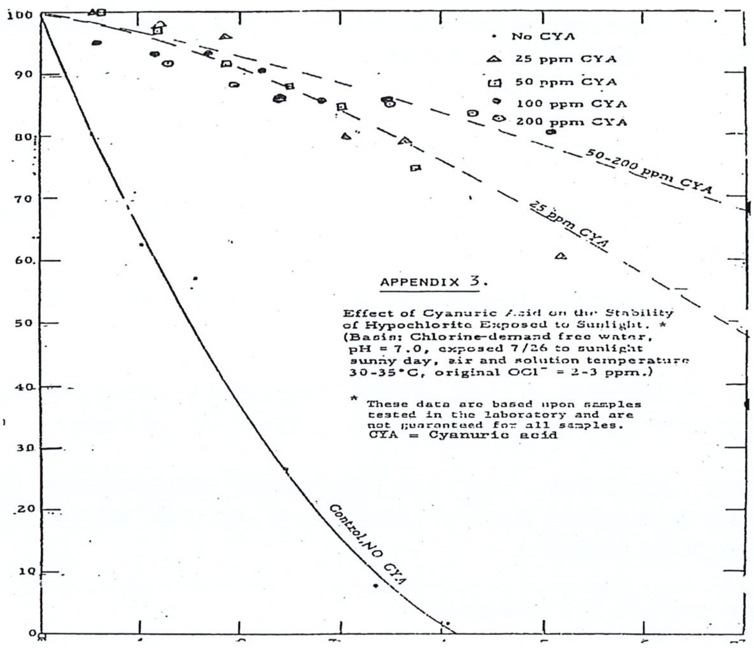

Hours 1 2 3 4 5 6 7 8

SAFE TRANSPORTATION OF SANITISERS

The safe transportation of sanitizers equally concerns the staff of pool shops who routinely carry these chemicals to be used on site or providing home delivery service and the pool owners who purchase their requirements and carry the chemicals home in the family car.

The following safety precautions should be followed to prevent accidents, injury to people and expensive damage to the car or other items:

1. The car becomes very hot during the summer when parked in the sun. Avoid storing chemicals in the hot car if possible. When shopping leave the purchase of chemicals as the last stop. Once bought take the chemicals straight home. Servicemen should carry small amounts of chlorine-based chemicals. Park the vehicle in the shade if possible.

2. Secure the chemicals in the car so that they do not get loose and roll around during travelling.

3. Segregate the chemicals in the car. ***Keep chlorines separate from acid, petrol, paint thinners*** etc. Cardboard boxes are useful to keep the containers segregated.

4. Liquid containers should be kept upright and the caps tightened before moving. Plastics bags are usually available and provide added safety against spillage.

5. Home pool owners should be encouraged to buy smaller quantities of sanitizers. They are easier to handle and safer to store.

SAFE STORAGE AND USE OF CHEMICALS

Chemicals have a potential hazard in the hands of inexperienced or immature people and children. The following safety procedures should be maintained to ensure safety to people and property:

The chemicals should be stored in a clean, well ventilated room which is locked when not in use.

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Segregate chemicals by keeping the chlorines separate from each other and from acids. Place chemicals, like sodium bicarbonate, algaecides, water clarifier etc. between the containers.
Store liquids on the lowest water clarifier etc. between the containers.

Store liquids on the lowest level to prevent spillage and contamination of solid chemicals underneath.

Open chlorine containers outside. Avoid breathing its vapour or dust. The scoop or cup must be clean and dry. Reseal the container well after opening.

Do not mix chemicals together, use them separately. The best method is to dissolve the product in a plastics bucket of water before adding to the pool.

Always add the chemical to the water. Adding water to the dry chemical my result in vigourous reactions and lead to accidents. When adding the chemical to the water use a wooden stick to mix to aid dissolving.

Avoid contact with chlorine compounds. They bleach clothes and may discolour pool surrounds. Clean up spills immediately either by scooping or washing away with plenty of water. Do not add chlorines to the waste bin. Flush it down in toilets or in washing tubs with plenty of water.

Rinse out empty containers with water and add to the waste bin

Chlorines may bleach or cause blistering of certain pool finishes.

The pool builder can advise whether it is safe to add solid chlorine to the pool. If the chlorine is added directly to the pool it should be scattered to avoid accumulation of the granules on the floor of the pool. Never drop tablets directly into the pool.

Do not add chemicals to the pool while people are using it. If dosed, allow sufficient time for the chemicals to disperse. Do not allow children to play with floats containing tablets.

BROMINATING COMPOUNDS

Bromine in the elemental form is a brown, fuming, very corrosive liquid. It is NOT used for pool water sanitization in this form as it is too dangerous for the average pool owner.

The product which is available for pool use is the "BROMINE STICKS". The product contains brominated hydantoin and about 12% chlorine. It cannot be "stabilized" against sun light and its half life is about 30 minutes. This means that there is very little bactericidal activity of the bromine left after 4 hours of sunshine. This together with its relatively high price make it uneconomical for outdoor pools. However, it is a popular choice for indoor pools and spas as the sticks are completely soluble, they do not effect the chemical balance of the pool water, it can be automated and it does not have the chlorine odour associated with the chlorine-based sanitizers.

Bromine reacts in a similar manner to chlorine in the pool water. It is a good bactricide-algaecide and it destroys organic waste the same as chlorine. A marked difference is the lack of odour and irritation of the bromanines.

Bromine sticks are slow dissolving and they are not suitable for "superbromination". Liquid or granular chlorine are used to destroy bromamines without affecting the other advantages of the bromine sticks.

Bromine can be generated from sodium bromide with the use of various chlorine compounds or strong oxidizing compounds like potassium monopersulphate. The method is still in its experimental state and constant attention is required to maintain adequate sanitization.

IODINE COMPOUNDS

Iodine in its elemental form is a dark brown to black solid which is very little soluble in water and it is not used in this form.

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In pools it is generated from potassium or sodium iodide with the aid of chlorine or other oxidizing agent. Iodine has good bactericidal properties, however, it is not powerful enough to destroy the contaminates introduced by the bathers. It is expensive, also it is liable to stain the pool if too much iodine is present. In brief iodine is not recommended for pool sanitisation.

POLYMERIC BIGUANIDE - HYDROGEN PEROXIDE SYSTEM

This is a non-chlorine sanitizing system. The polymeric biguanide should be maintained in the water between 5 and 10mg/L at all times. In addition hydrogen peroxide should be added at least once a month.

The polymeric biguanide is not compatible with chlorine and chlorine has to be eliminated even from the make-up water using sodium thiosulphate.

The polymeric biguanide is uneffected by the UV rays of the sun and a stabilizer is not required. However, it acts as a flocculant and tends to block up the filter, therefore more backwashing or a larger filter is necessary when using this system.

SILVER - COPPER WATER PURIFIER SYSTEM

Due to the application of an electric current silver and copper ions are released into the water. The silver ions are claimed to destroy the bacteria and the copper ions control the algae. The system must be used in conjunction with chlorine and it does not provide any advantage over straight chlorination. In addition staining can occur if excess silver or copper ions are produced. Also silver is harmful to health if it is in excess of 0.1 mg/L in the pool water. This system is not recommended for pool water sanitization.

OZONE

Ozone O^3 is an effective – and poisonous - gas which is an extremely effective bactericide and algaecide, however, because of its poisonous nature ozone residual gas created by Corona Discharge units is not permitted in Commercial Swimming Pool pool water, so ozone treated water must be treated by “washing out” before returning to the swimming pool - thus the CD system is not usually recommended for residential swimming pools.

The alternative is the less productive (milder) O^3 produced by Ultraviolet (UV) units, and which have become the ‘Standard’ for spa pools and is becoming common in home swimming pools.

UV RADIATION

UV radiation is capable to destroy bacteria and algae in close range, however, it is not effective in the water if it is further away from the source. Also, it is harmful to the eyes of swimmers when the source is on. It is not recommended for sanitization of the pool water.

CHLORINATING COMPOUNDS

To calculate the dosing of pool water with chlorinating compounds:

STEP 1: Calculate the available chlorine content of the chlorinating compound:

$$\frac{\text{Assay \%}}{100} = C$$

Example: Granular pool chlorine contains 65% available chlorine.

$$\frac{65}{100} = 0.65$$

$$\frac{\text{Assay g/Kg or L}}{1{,}000} = C$$

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Example: Liquid pool chlorine contains 125 g/L available chlorine:

$\frac{125}{1,000} = 0.125$

STEP 2: Decide target chlorine content mg/L in the pool - T
Establish volume of pool, litres - L
$\frac{T\ (target) \times L\ (volume)}{1,000,000 \times C\ (from\ Step\ 1)} =$ kg chlorinating compound

Example: Target chlorine 3 mg/L
Volume of pool 50,000 L
Chlorinating compound - stabilized chlorine, 600 mg/kg
$C = \frac{600}{1,000} = 0.6$

3 x 50,000 = 15 =0.25 kg or 250 g stabilized
1,000,000 x 0.6 60 chlorine

CALCULATING COST OF CHLORINATING COMPOUNDS

Step 1: Calculate quantity of chlorinating compound as in previous example.
Step 2: Establish cost of chlorinating compound per kg.
Step 3: Multiply cost/kg as quantity required, kg.

Example:

Step 1: Quantity of chlorinating compound (stabilized chlorine) 0.25 kg per day.
Step 2: A 10 kg bucket costs $75
Cost of 1 kg = $7.50
Step 3: 7.50 x 0.25 = $1.88 per day

Carry out calculations for cost comparisons of different sanitizers as above.

OPERATING SPAS & HOT TUBS
(By : GEORGE GORGENYI - AJAX CHEMICALS, Australia)

There are two Australian/New Zealand standards for the construction, maintenance and use of spas:

AS/NZS 2610, Part 1-1983 PUBLIC SPAS
AS/NZS 2610, Part 201983 PRIVATE SPAS

The text below should be read in conjunction with the above standards.

A SPA/HOT TUB means a water-retaining structure of at least 660 L or more capacity, fitted out with equipment to heat the water in it and injecting jets of air-bubbles or jets of turbulent water.

HOT TUB referees to a wooden structure, while SPA refers to all other forms and materials of construction. As the criteria are the same for both the name SPA will be used below.

The maintenance of the spa is somewhat different from that of a pool because:

- less water per person is used
- the temperature of the water is higher because it is heated
- the water is aerated
- the water is continuously filtered

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OPERATION OF THE SPA

The operation of the spa is as follows:

1. The spa has to be filled to the correct operating level with water and maintained there when used. Low water level may cause damage to the pump or heater.
2. The skimmer basket and the pump strainer basket should be checked and cleaned regularly to ensure unrestricted flow fo the water.
3. The filter should be checked and cleaned frequently. Soaking in tri-sodium phosphate will remove body fats and oils which tend to cling to the surface of the filter cartridge restricting the flow of water.
4. It is a good policy to drain the water, say every 4-6 months, depending on use, to eliminate the build-up of chemicals, e.g. chloramines, etc. After draining the interior of the spa should be cleaned with a sponge and mild detergent. After cleaning all traces of the detergent must be removed to prevent excessive foaming during operation.
5. The calcium hardness should be adjusted to about 100 mg/L and the total alkalinity to 90-100 mg/L in reactive finished spas, like marblesheen, etc. In all other spas the calcium hardness should be kept as low as possible, the total alkalinity should be adjusted to 60 to 80 mg/L.

NOTE:

Due to heating of the water some of the sodium bicarbonate will break down and this will increase the pH of the water. The high pH is undesirable as it may cause skin problems, also it may cause damage to the wooden tubs. If the pH is 8 or higher it should be lowered with hydrochloric acid and the total alkalinity should be re-adjusted with sodium bicarbonate.

6. It is a good policy to add some scale dispersant as this will minimise scaling on the heater's surface and in the pipe line immediately after the heater.
7. For sanitization sodium hypochlorite solution or 'bromine sticks' should be used. Stabilised chlorines are not recommended for spas, especially in those indoors. Calcium hypochlorite increases the hardness therefore it is not recommended either.

ROUTINE MAINTENANCE

Daily:

1. Energy should be preserved by covering the spa when it is not in use.
2. The sanitizer should be added to the water at least half an hour prior to use.
3. Foam suppressant may be added as required, however, if foaming is persistent, draining part or all of the water is recommended.

Weekly

1. The pH and total alkalinity should be tested and adjusted as required.
2. The water should be superchlorinated with 4-5 times the daily dose. Superchlorination should be carried out every time when the 'chlorine odour' becomes noticeable.
3. The scale dispersant should be replenished.
4. The filter should be checked and cleaned as required. The lint baskets should be cleaned.
5. The water level should be topped up as required.

SAFETY PRECAUTIONS

1. Pregnant women, elderly persons and those suffering from heart disease, diabetes, high or low blood pressure should not enter the spa without first seeking medical advice.
2. Children should not use the spa without adult supervision.
3. Those under the influence of alcohol or drugs should not use the spa.
4. The spa should not be used alone.
5. The spa should not be used longer than 10-15 minutes at the time. After the spa is slow cooling down is recommended. Long exposures may cause dizziness, nausea or even fainting.
6. The jets of water/air are very powerful and they should be treated with caution to avoid injury or discomfort.
7. The head should not be put under water. This warning should be displayed for all users to see.

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POOL WATER SANITISATION

A sanitizer is a type of disinfectant which is used to kill germs. A pool water sanitizer is also a bactericide as well as an algaecide in the form of a compound or system.

There are a number of sanitizers on the market and the large variety of brands and types tends to cause confusion. In this section the properties of the various sanitizers will be discussed to make the right choice easier when a sanitizer is recommended by the pool technicians.

GENERAL REQUIREMENTS

Before considering the properties of sanitizers let's consider the requirements the sanitizers have to achieve:

a. To prevent infection or the spread of disease amongst bathers by quickly killing bacteria, viruses, amoeba etc.

b. To help preserve the clarity of water by preventing the growth of algae.

c. To eliminate obnoxious odours, tastes, also pollutants introduced by the bathers, e.g. perspiration, urine, etc.

d. Sanitizers should not cause any unacceptable taste, odour or colour. They should not cause any irritation to the eyes, throat or skin or cause any allergic reaction.

e. To be easy to handle and safe to use.

f. It should not damage the pool's interior or its surrounding.

g. Be readily available at an affordable price.

When we examine the above requirements we have a specification that is hard to meet. Therefore it is necessary to evaluate the properties of the individual sanitizers and to be able to select the most suitable one.

WATER QUALITY AND MAINTENANCE

A pool owner need not be a chemist to master the fundamentals of water chemistry. By monitoring only a few conditions and adding only a handful of chemicals, he can keep the pool safe, sanitized and sparkling. The key to proper water treatment is an understanding of the way chemicals act and interact in the pool water, and essential to this concept are demand and balance.

Demand represents the water's need for chemicals and disinfectants. Low demands indicate a properly conditioned and maintained pool. Only small quantities of chemicals are required to make adjustments in a pool that consistently shows a low demand. Demand increases after heavy usage, but in a well-kept pool, after testing the water and adding the chemicals required, the pool is easily brought back into adjustment.

Demand increased drastically if the pool is haphazardly maintained. In such a pool, the demand and the potential for problems and damage to both the pool finish or liner and equipment are high. Where a minimum effort would have been required, now expensive procedures will be required to bring the pool back to normal.

Balance is the other significant concept in chemical maintenance. A pool is said to be in balance when the chemicals are all within the recommended ranges. When the sanitiser, pH, alkalinity, hardness and temperature are at desired levels, the chemicals are working most efficiently and the pool is most easily and economically maintained.

A regular testing and maintenance routine will result in diminished demand and the desired balance - a stable and easily maintained pool. A regularly administered chemical treatment also ensures that characteristics of water vary so much from area to area that we can provide no set formula for the addition of chemicals. The best dates added, amounts, results, and so on. Over a period of time, a pattern should emerge; this pattern will be the normal treatment routine. The routine will not, of course, eliminate the need to test and analyze the water, but it will serve as a useful maintenance tool and enable the pool owner to identify abnormal conditions almost immediately.

The chemical balance deals with the interaction of pH, temperature, total hardness, total dissolved solids and total alkalinity of the water. These five factors can be given numerical values and applied to a formula known as the Langelier Index.

The Langelier Index indicates whether a particular water has scale-forming or corrosive tendencies and what can be done to correct this condition. In the Langelier table the numerical values are given for three of the five factors.

An average factor for total dissolved solids is included in the formula.

Using figures from the table and the following simplified version of the Langelier formula, the proper chemical balance of a pool water and hence its ability to resist scale-forming or corrosive tendencies - can be obtained.

Saturation Index = pH + TF + HF + AF - 12.1

pH	Actual Reading
TF	Temperature Factor
HF	Total Hardness Factor
AF	Total Alkalinity Factor

Temp	TF	Total Hardness Expressed as ppm $CaCO_3$	HF	Total Alkalinity Expressed as ppm $CaCO_3$	AF
0	0.0	5	0.3	5	0.7
3	0.1	25	1.0	25	1.4
8	0.2	50	1.3	50	1.7
12	0.3	75	1.5	75	1.9
16	0.4	100	1.6	100	2.0
19	0.5	150	1.8	150	2.2
24	0.6	200	1.9	200	2.3
29	0.7	300	2.1	300	2.5
34	0.8	400	2.2	400	2.6
41	0.9	800	2.5	800	2.9
53	1.0	1,000	2.6	1,000	3.0

Interpretation

1. If the index is a minus quantity, corrosive tendencies are indicated.
2. If the index is a plus quantity, scale-forming tendencies are indicated.
3. The water is chemically in balance and it is considered satisfactory if the value of the saturation index is between + 0.3 and - 0.3.

Examples for the use of the saturation index formula re given below:

1. pH 7.2
   Temperature 19oC
   Total Hardness 5 ppm
   Total Alkalinity 5 ppm
   Saturation Index 7.2 + 0.5 + 0.3 + 0.7 - 12.1 = -3.4

This is fairly pure water, but it is very corrosive, particularly in Marblesheen finish.

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2.

pH	7.6
Temperature	24 C
Total Hardness	200 ppm
Total Alkalinity	120 ppm
Saturation Index	7.6 + 0.6 + 1.9 + 2.1 - 12.1 = 0

This is ideal water

It is important to understand the significant components of water balance and how to correctly balance when there is a problem.

The Hardness of Environmental Water

The term 'HARDNESS' originates from the observation that it was 'HARD' to produce a foam with soap in waters rich in calcium and magnesium salts. The source of the dissolved solids is in the soil and magnesium salts it dissolves trace amounts of heavy metal salts like those of iron, aluminium, manganese, etc. Salts of sodium and potassium are also present - however, they are not hardness-forming.

The following terms are used in connection with hardness:

<u>TEMPORARY HARDNESS</u> - is formed by bicarbonates of the alkaline earth metals and it is equivalent to the alkalinity of the sample, expressed as calcium carbonate ppm. It is so called because heating will decompose them to form insoluble carbonates which can be filtered out and thus effectively reduce hardness.

<u>PERMANENT HARDNESS</u> - includes the other soluble alkaline salts, like chlorides, sulphates, etc. Their quantity is expressed as calcium carbonate ppm. The permanent hardness does not change due to heating and it cannot be filtered out.

The sum of the temporary and permanent hardness is called TOTAL HARDNESS. The reaction of calcium bicarbonate-carbonate is of special interest to the pool owner because it explains the presence of hardness in the natural water and also the scale formation in the pool and in the water heater.

	Scale & turbidity forms due to heat					
Ca (HCO3)	$\rightleftarrows$	CaCO3	+	H20	+	CO2
Calcium bicarbonate water-soluble	Limestone dissolves, hardness forms in water			Calcium Carbonate water-insoluble	Water	Carbon dioxide

The natural water, after absorbing carbon dioxide from the air, dissolves limestone or dolomite (the reaction proceeds from right to left). The scale formation is due to the breakdown of this dissolved calcium bicarbonate by heat (the reaction proceeds from left to right).

The 'HARDNESS' in the water is expressed as calcium carbonate (ppm or mg/litre).
This does not mean that all the hardness present is calcium carbonate, rather it is used for convenience.

Water supplies are arbitrarily classified according to their hardness as follows:

CLASSIFICATION	TOTAL HARDNESS AS CALCIUM CARBONATE ppm (mg/L)
Soft Water	Under 60
Moderately hard	61 - 120
Hard	121 - 180

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Very Hard	Over 180

HARDNESS IN SWIMMING POOL WATER

The range of 100 ppm to 300 ppm (as calcium carbonate) hardness is recommended in swimming pools, although the optimum level depends on other conditions as well (see THE CHEMICAL BALANCE OF POOL WATER) page
Low level of hardness is desirable in fibreglass and vinyl pools, while the same low hardness-containing water may dissolve significant amounts of calcium from the Marble Sheen finish of concrete pools. Therefore, in the latter pool a higher level of hardness is advisable.

LOWERING OF THE HARDNESS OF THE POOL WATER

The hardness-forming chemicals accumulate in the water since the only natural lowering occurs when the filter is backwashed and when the water is splashed out. Topping of the level of water, evaporation and calcium-based chlorinating compounds will increase the hardness and could lead to scaling.

1. Discharging part of the pool water, however, this is wasteful and requires soft water for topping up
2. Softening the water, and this is carried out as follows:-

Determine the level of hardness and add 1 mg/L (ppm) of soda ash for each mg/L (ppm) of hardness that has to be removed.

Example: The actual hardness was found to be 700 ppm or mg/L. The required hardness, after softening in 200 ppm or mg/L 700-200 = 500 ppm or mg/L has to be removed. This requires 500 ppm or mg/L has to be removed. 500 ppm or mg/L equal to 0.5 g/litre, or 5 kg SODA ASH for every 10,000 litres of pool water.

After adding the SODA ASH the water becomes turbid due to the insoluble calcium carbonate formation. Ensure thorough mixing by 2-3 hours of circulation of the water through the pump. When thoroughly mixed add POOL WATER CLARIFIER at the rate of 50 ml/10,000 L pool water. Mix it in thoroughly by agitating the water for about 60 minutes. Do NOT over-agitate the water. Allow the solids to settle overnight. Remove the sediment by vacuuming it out next day. If the water is still turbid, repeat the dosing with POOL WATER CLARIFIER. Vacuum the sediment, and filter until it is clear. A third application of the CLARIFIER is not recommended.

Next check the pH, and if necessary adjust it to the optimum range.

Determine the TOTAL ALKALINITY and adjust it to the optimum level.

After the pH BUFFER is mixed in, chlorinate the pool using the average daily dose. The pool is now in a good condition and is ready for use.

INCREASING THE HARDNESS OF THE POOL WATER

To increase the hardness in the pool water, 1.5 kg of calcium chloride dehydrate added to 10,000 litres of water will increase the hardness by 100 ppm. This procedure is only advisable if full chemical testing methods are available. It should be remembered that the calciumions will be precipitated by carbonates if present and it will lead to turbid water and blocking of the filter.

THE pH OF WATER

The pH is a value which is related to the hydrogenion concentration in the water. The pH values are arranged to form a scale from 0-14. pH 7 is neutral. A value less than 7 indicates acidity and the higher the concentration of the hydrogenion which are produced by the acids, the lower is the pH. Above pH 7 the water is alkaline and the greater the concentration of the alkalinity-producing chemicals the higher is the pH. The diagram on the following page gives a graphic explanation of the pH scale.

THE pH OF THE POOL WATER

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The pH 7.2 - 7.6 is the most frequently recommended range for swimming pools, although sometime in fibreglass pools the pH may be kept as low at 7.0 to prevent scale formation. It should be pointed out that at such a low pH value there is very little if any reserve alkalinity to buffer the water and small amounts of acid or alkali will cause significant changes to the pH of the pool water.

ADJUSTING THE pH OF THE POOL WATER

Test the pH weekly.
If the pH is below 7.2 add pH Buffer, or if the pH is above 7.8 add DRY ACID as indicated on the table below.

Note, that these quantities are only approximate because the pH by itself is not an accurate indication of the DRY ACID or pH BUFFER requirement. A more accurate determination of the acid or alkali demand is described next:

TOTAL ALKALINITY

The total alkalinity is the quantitative of all the alkaline chemicals present, like hydroxides, bicarbonates and soluble carbonates in the pool water and expressed as calcium carbonate ppm. They act as a buffer against rapid changes of the pH, keeping it more or less constant. The optimum range of total alkalinity in swimming pools is 100-120 ppm (as calcium carbonate). Once adjusted, the total alkalinity remains fairly constant, unless acidic chemicals, like the long lasting chlorine tablets, are used. A monthly check of the total alkalinity during the season is recommended.

ADJUSTING THE TOTAL ALKALINITY IN THE POOL WATER

The method of adjustment is to determine the actual Total Alkalinity first by using a suitable test kit. For each ppm calcium carbonate by which the total alkalinity is less than 100 ppm, add 1.7 (or mg/L) pH BUFFER.

Example: The actual total alkalinity was found to be 80 ppm.
This is 20 ppm loss than that required. Therefore, add
20 x 1.7 ppm (or mg/L) pH BUFFER, which is equal to
34 mg/L pH BUFFER for each 10,000 litres of pool water.

SODA ASH OR pH BUFFER?

Small quantities of SODA ASH will raise the pH rapidly and small overdoses can make the water very alkaline, without providing sufficient buffering capacity. The addition of pH BUFFER will raise the pH of the water slowly; it provides a good buffering capacity and small overdoses will not cause excessive alkalinity of the water. The pH BUFFER is not suitable for lowering the hardness or for the removal of coloured ions.

ACID DEMAND

If the water is too alkaline it may be adjusted as follows:-

Calculate the excess alkalinity present, i.e. Actual total alkalinity ppm - 120 ppm =
excess alkalinity ppm.
For each ppm of excess alkalinity add 2.4 ppm
of DRY ACID or 2 ppm of HYDROCHLORIC ACID.

Example: The total alkalinity was found to be 210 ppm.
It is to be lowered to 120 ppm:
210 - 120 = 90 ppm excess alkalinity
The volume of the pool water is 50,000 litres

$$\frac{90 \times 2.4 \times 50{,}000}{1{,}000{,}000} = \frac{90 \times 2.4 \times 5}{100} = 10.8 \text{ Kg R70 DRY ACID}$$

OR

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90 X 1 X 5 = 9 Litres of R70 HYDROCHLORIC ACID
100
is required.

TOTAL DISSOLVED SOLIDS

The total dissolved solids represent all the soluble salts and organic matter which are dissolved in the water. Some are coloured, however, most of them are colourless. The most common soluble salts in swimming pools are sodium and calcium chlorides and bicarbonates, and they originate both from the water supply and from the chemicals added during treatment. Some organic matter is in the ground water, but most of it is carried into the pool water by the people who use it and regular chlorination and filtration will control these organic impurities and they will not accumulate to any significant extent. The quantity of the TOTAL DISSOLVED SOLIDS is expressed as ppm (or mg/litre). In fresh water pools 300 to 1000 ppm of dissolved solids are quite acceptable.

In excess of 1500 ppm, scaling on the walls and pipes or corrosion dissolved solids is by pumping out part of the water and by replacing it with good quality fresh water. Salt water pools may contain as much as 3.5% of salts and these pools require attention to minimize damage to the pool structure and accessories.

THE CHEMICAL BALANCE OF THE POOL WATER

Once the water is in balance it is essential that the pool water is sanitised using:

1. Calcium Hypochlorite
2. Sodium dichlorisocyanuate (stabilised chlorine)
3. Trichloroisocyanuric Acid
4. Electrolytic systems which generate Hypochlorous Acid (Salt water chlorinators)
5. Chlorine Gas
6. Halgens (Bromine)
7. Biguanide

The action and reaction of these sanitise systems are covered in another PAPER, but it is important to consider the importance of the stabilisation of pool water in maintaining efficient sanitiser levels for extended periods.

Possibly the most significant factor in maintaining a clean, efficient pool in ensuring that the pool has a good filtration system. Once again this is covered in another PAPER, but a system which can turn over the total pool volume in 6 to 7 hours will reduce the amount of insoluble matter in the pool, ensure that chemicals are properly mixed and even remove types of free swimming algae.

Automatic cleaning systems also assist in removing organic debris from the pool water. This removal allows the pool's sanitiser to function as a batericide/algaecide.

In summary a well balanced pool is one where:

a. The Langelier Index is within + 0 3
b. The filtration system can turnover the total volume of water in 6-7 hours.
c. Sanitiser levels are maintained for extended periods.

A pool with the above is more efficient, less demanding chemically and usually free from staining and organic growths.

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