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Breakfast Webinar

Chemistry of Chlorinated Swimming Pool Water

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Pool Water Limits

Pool	Min	Max	Comments
Free Cl	1	5	Most pools should not need to above 3
Combined Cl	-	< 1	
pH	7.2	7.4	
TDS	No more than 1000 greater than supply		

Spa	Min	Max	Comments
Free Cl	3	5	
Combined Cl	-	< 1	
pH	7.0	7.6	
TDS	No more than 1000 greater than supply		

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Pool Water Limits

Alkalinity 80-200mg/l

A measure of dissolved alkaline salts. Can be raised by adding Sodium Bicarbonate.

Hardness 75-150mg/l as $CaCO_3$

Total hardness is all dissolved calcium and magnesium salts. Hardness less than 40mg/l as $CaCO_3$ may be corrosive.

Sulphate <360mg/l

High sulphate can attack cement and cementitious grout.

Chloride <720mg/l

High chloride levels can cause corrosion of metallic elements within the pool and pool system.

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Pool Water Limits

Metals (Iron, zinc & copper) <0.1mg/l

Can be from pool plant, play structure or algaecide (copper). Indicated possible failures. Can cause staining.

Permanganate Value (PV) <2mg/l as N

Oxidisabilty of the pool water.

Nitrogen Content <0.6mg/l as N

Inorganic – Ammoniacal nitrogen

Organic – Albuminoid nitrogen

Total Dissolved Solids (TDS) <1000 greater than supply

All dissolved solids in the pool water.

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Pool Water Testing

Langelier Index (Water balance)

Temp °C	TF	Ca Hardness	CF	Alkalinity	AF
19	0.5	75	1.5	50	1.7
24	0.6	100	1.6	100	2.0
29	0.7	150	1.8	150	2.2
34	0.8	200	1.9	200	2.3
41	0.9	300	2.1	300	2.6
-	-	400	2.3	-	-
-	-	800	2.5	-	-

Langellier index= TF + CF + AF + pH – 12.1

Positive number indicates scale forming water

Negative number indicates corrosive water

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Tool Testing Kits

Comparator

Uses a colour wheel. Requires good white light.

Photometer

Uses a light and sensor within the machine to measure levels. Cells and equipment need to be very clean. Cell must be dry when tested.

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Pool Testing Probes

Amperometric probe

Measures hypochlorous content of pool water. Can be calibrated with DPD1 tablets if pH is stable.

Redox probe

Measures the oxidative power of the pool water. Coarser control than amperometric.

pH probe

Electrode, usually inline with the chlorine probe. Calibrated with buffer solutions.

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Chemicals

Sodium hypochlorite

Liquid in various drum sizes. 10-15% W/W

Can be produced electrolytically by passing a current through sodium chloride solution or maintaining 2000-4000mg/l sodium chloride in water and passing through an electrolyser.

Calcium Hypochlorite

Tablets or granules in various sack/tub sizes. 65-68% available chlorine. Raises calcium hardness in pool water.

Isocyanurates

Two main forms, sodium dichlorocyanurate (dichlor) and trychloroisocyanuric acid (trichlor). When dissolved form hypochlorous acid and cyanuric acid. Often used in outdoor pools as the cyanuric acid stabilises the chlorine.

Chemicals

Isocyanurates

Cyanuric acid binds free chlorine, so a minimum level of free chlorine must be maintained.

Cyanuric acid (mg/l)	Minimum free chlorine (mg/l)
25	1.5
50	2.0
100	2.5
200	3.0

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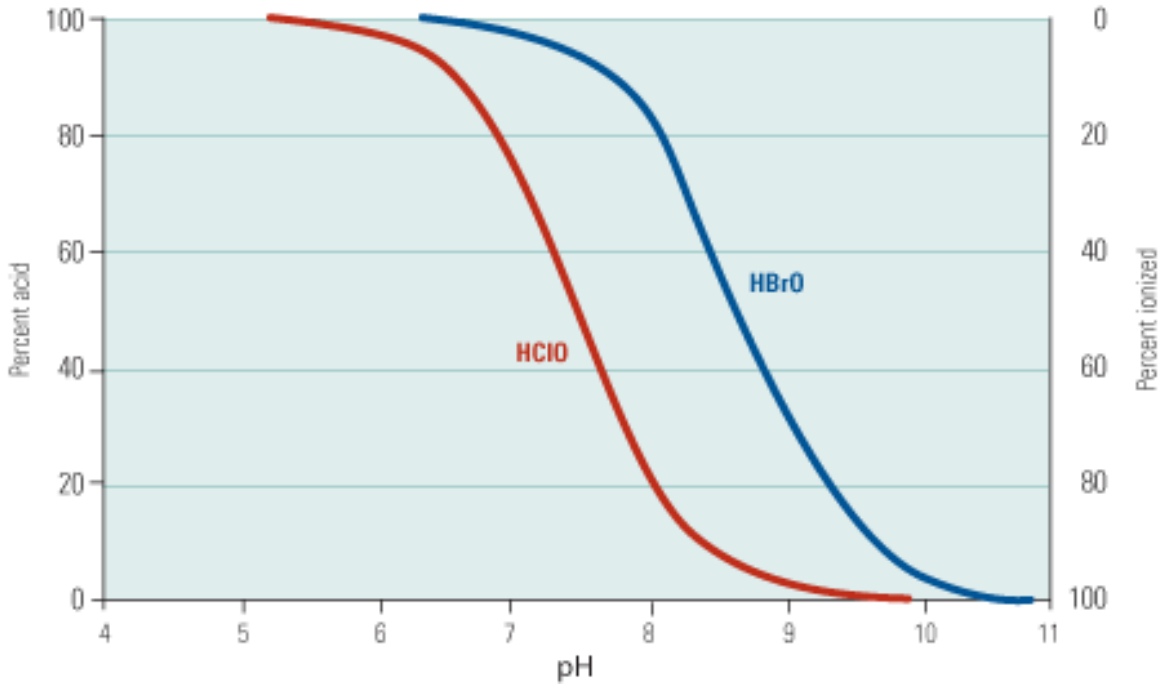
pH adjustment

The effectiveness of the chlorine is dependant on the pH value.



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pH adjustment

Hydrochoric acid

Liquid in various drums, usually 25% W/W.

Sodium bisulphate (Dry acid)

Granules in various size sacks/tubs. Will increase sulphate levels in the pool water.

CO_2

Effective where alkalinity is less than 150mg/l as $CaCO_3$.

Possible asphyxiation risk.

Sulphuric acid

Liquid in various size drums. 15% W/W. Will increase sulphate levels in the pool water.

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pH adjustment

Sodium carbonate (Soda ash)

Granules in various size drums.

Sodium hydroxide

Liquid in various size drums. 5% W/W

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Disinfection

The purpose of disinfection is to keep the pool water as sterile as possible.

Chlorine residual not just to eradicate bacteria it will also oxidise bather pollution, a source of nutrient for bacteria.

Which chlorine donor and pH correction should be used will depend upon the supply water chemistry. A test should be undertaken before installation to ensure suitability.

The chlorine donor produces hypochlorous acid in water:

$NaOCl + H_2O <> HOCl + Na^+ + OH^-$

$Ca(OCL)2 + 2H_2O <> 2HOCl + Ca^{++} + 2OH^-$

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Disinfection

Hypochlorous acid is a weak acid and react further.

$HOCl < > H^+ + OCl^-$

The reaction is dependant on pH level. The lower the pH the more the reaction favours the left side. Hypochlorous acid is a stronger disinfectant than the hypochlorite ion by a factor of almost 100.

Chlorine disinfection can be supplemented by ozone and UV.

These can be full bore or side stream disinfections.

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Disinfection By Products

Chlorine reacts with pollutants to form other products. One of the main pollutants is ammonia (NH_3).

Monochloramine

$HOCl + NH_3 > NH_2Cl + H_2O$

This is a normal reaction in pool water. Monochloramine is stable at normal pool pH levels.

Given enough hypochlorite the reaction will go further.

Dichloramine

$HOCl + NH_2Cl > NHCl_2 + H_2O$

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Disinfection By Products

Dichloramine is less soluble and can irritate eyes and nose.

It is unstable and can decompose like this:

$NH_2Cl + NHCl_2 > 3HCl + N_2$

This is a crucial part of “Breakpoint” chlorination. The combined chlorine will drop towards zero. Free chlorine has no chlorine to react with and will form a residual. The reactions are slow (up to 1 hour).

The free chlorine needs to be double the combined chlorine, with the combined less than 1mg/l.

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Disinfection By Products

If the combined chlorine is high or the pool overloaded a further reaction can occur.

Trichloramine

$HOCl + NHCl_2 > HCl + NCL_3$

This is the most volatile chloramine, largely responsible for the “chlorine smell” in pool halls. Can be a factor in asthma complaints.

Trihalomethanes (THMs)

Based on the substitution of three of methanes four hydrogen atoms. The main THM formed is chloroform ($CHCl_3$), which can be carcinogenic.

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Questions and Discussion

Any Questions?