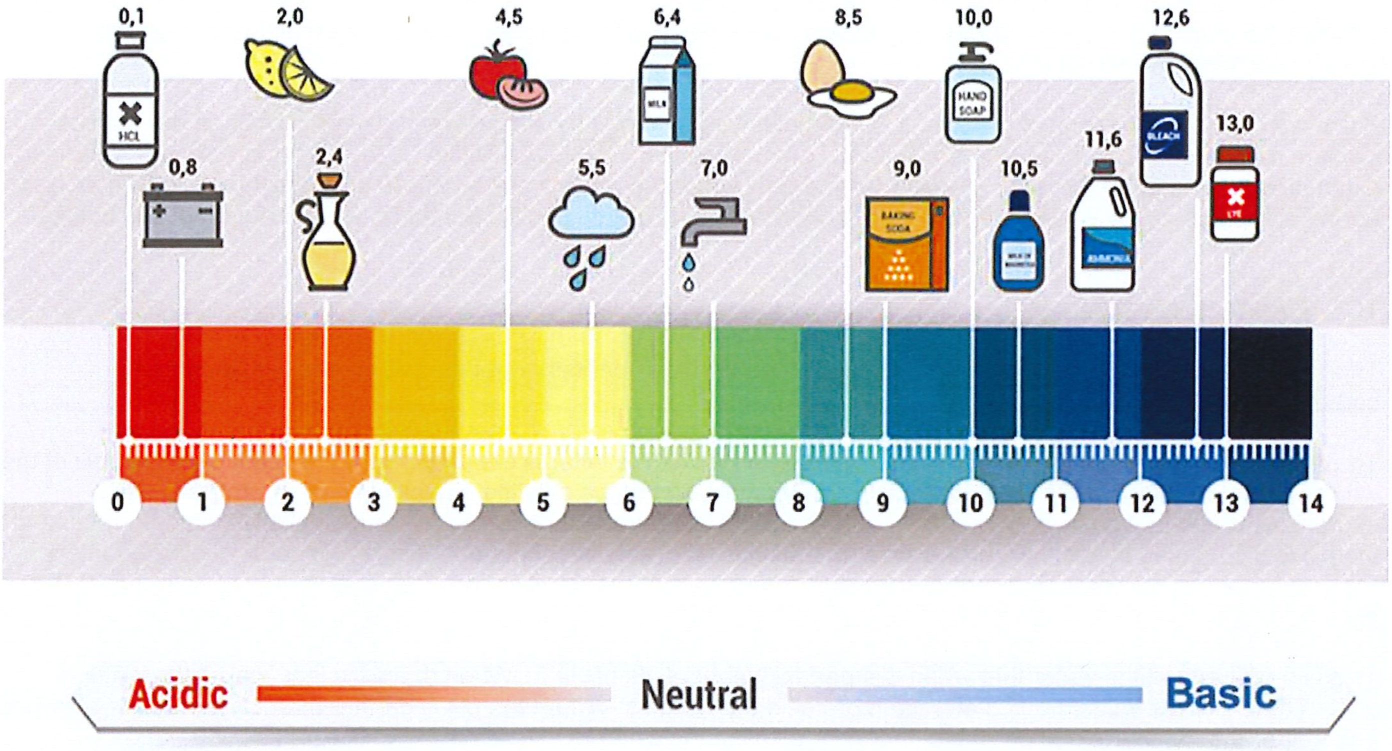
New Zealand Pool Industry Association Inc, PO Box 17069 Greenlane Auckland 1546 – email executive@poolguild.org.nz

PAPER 7
Background Information

THE DESIRED CHEMICAL BALANCE IN SWIMMING POOL WATER



Since it is rare to find swimming pool water which is in perfect equilibrium with the pool's interior, chemical treatment is required to correct the imbalance in the solids content of the water.

It is necessary to bring the water to the point of equilibrium by adding certain chemicals in the right proportion, rather than wait until equilibrium is achieved naturally.

CHEMICAL BALANCING means the adding of specified quantities of chemicals to the pool water to achieve equilibrium between the pool water and the internal (plaster) surface of the pool.

The correct chemical balance is very important as it has an effect on:

THE CHLORINE AND BROMINE-BASED SANITSERS' EFFICIENCY - and this is directly related to bathers' health.

BATHERS' COMFORT - by reducing or eliminating the risk of dry skin, sore eye, etc.

THE CONDITION OF THE POOL'S INTERIOR, FITTINGS AND EQUIPMENT - pump, rails, lights, etc.

THE AESTHETIC APPEAL - to eliminate "milkiness", discolouration.

The chemical balance of the pool water is the combined effect of:

CALCIUM HARDNESS (CaH)
TOTAL ALKALINITY (TA)
pH
TEMPERATURE (t)
TOTAL DISSOLVED SOLIDS (TDS)

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The above properties of the water are discussed below.

CALCIUM HARDNESS (CaH)

This is the total amount of calcium compounds DISSOLVED in the water. It includes many different compounds like the chloride, sulphate, bicarbonate as long as they are dissolved in the water. The milkiness-forming insoluble calcium compounds are not included.

Since we do not know (most of the time it is not necessary to know) the actual identity or proportion of the various calcium compounds, rather we express the total amount as CALCIUM CARBONATE (even though calcium carbonate is not present - or it should not be present - in the pool water) as milligrams per litre (mg/L - previously known as parts per million). These two values are identical, however, mg/L is more specific and this is used throughout this course.

TOTAL ALKALINITY (TA)

This is the amount of all of the alkaline chemicals (usually bicarbonates) together and expressed as calcium carbonate, mg/L.

The ***total alkalinity*** should not be confused with ***alkalinity*** as the latter is the property of the water when the pH of the water is greater than 7, while total alkalinity is the total amount of the alkaline chemicals present in the water, expressed as mg/L of calcium carbonate. An example is bore-water that could have a total alkalinity of 300 mg/L and the pH is 6.5 caused by excess carbon dioxide, thus it is NOT alkaline although it has a high total alkalinity content.

pH

This is a property of the water that when it is perfectly neutral, its pH is 7. When the pH is less than 7 the water is acid. The lower the value, i.e. 5.3 etc. the more acid the water is. When the pH is greater than 7 the water is alkaline. The higher the number, i.e. 8 or 10 etc. the more alkaline the water is.

The usual pH range of the swimming pool water is between 7.2 and 7.6, thus it is slightly alkaline.

It is important to remember that the pH scale is logarithmic, which means that the water is ten times more acidic at pH 5 than at pH 6 and it requires ten times more alkaline chemicals to increase the pH from 5 to pH 6 than from pH 6 to pH 7. Similarly the water is ten times more alkaline at pH 9 than at pH 8 and it takes ten times more acid to lower the pH from 9 to 8 than from pH 8 to pH7.

TOTAL DISSOLVED SOLIDS (TDS)

As the name indicates the solids ***must be dissolved*** to count, like salt, total alkalinity etc. Solids which are not dissolved should not be included, like mud, dirt, leaves, swimmers, etc. The TDS cannot be removed from the water by filtration, while mud, leaves etc, can be, hence it is a ready distinction between the two kinds of solids.

SATURATION INDEX (SI)

Once we have measured each of the above values of particular water, we can evaluate its property by calculating the SATURATION INDEX.

The formula for the calculation was developed in 1936 by Professor Bill Langlier of the University of Southern California (U.S.A.).

Contemporary pool builders rely less on the SI these days, as it describes the condition of the sample, and suggests thstthe pH be altered to bring the water into balance, whereas it is generally agreed nowadays that the pH is better left at 7.6 and OTHER indicators altered, rather than the other way around. Nevertheless, here is the full information – should you evern need it!

These days, we find it easier to use an on-line calculator such as this one:

http://www.csgnetwork.com/langeliersicalc.html

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In this formula we use.

CaH + TA + pH + T - 12.1

However, instead of the actual concentrations we use factors for the above values and the formula will look like:

SI = pH + TF + HF + AF - 12.1 *

The number 12.1 is a correction factor for the TDS ad this value is used when the TDS is less than 1000 mg/L. If the value of TDS is higher than 1000 mg/L, like in the salt-containing pool waters, the value of 12.2 should be used.

The calculation of some examples below will show the condition of the various water samples.

(Thank goodness for computers! – Editor)

EXAMPLE 1.

*

ACTUAL VALUES		FACTORS *	
pH	7.7	pH	7.7
T	24.C	TF	0.6
CaH	150 mg/L	HF	1.8
TA	100 mg/L	AF	2.0
TDS	<1000 mg/L		-12.1

SI = 7.7 + 0.6 + 1.8 + 2.0 - 12.1 + 0

When the SATURATION INDEX is zero (0) it means that the water is saturated and it is in equilibrium with the wall of a marblesheen pool Since the chemicals are in the correct proportions to each other the water is called BALANCED WATER.

EXAMPLE 2.

Ph	7.6	pH	7.6
T	19C	TF	0.5
CaH	400 mg/L	HF	2.2
TA	80 mg/L	AF	1.9
TDS	>1000 mg/L		-12.2

SI = 7.6 + 0.5 + 2.2 + 1.9 - 12.2 = 0

This is another example of a perfectly balanced water.

EXAMPLE 3.

pH	7.9	pH	7.9
T	24.C	TF	0.6
CaH	400 mg/L	HF	2.2
TA	150 mg/L	AF	2.2
TDS	<1000 mg/L		-12.1

SI = 7.9 + 0.6 + 2.2 + 2.2 -12.1 = 0.8

When the saturation index is POSITIVE - as in example 3 - the water is over-saturated, it is scale-forming and it is likely to be "milky".

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EXAMPLE 4.

pH	7.5	pH	7.5
T	19 C	TF	0.5
CaH	50 mg/L	HF	1.3
TA	60 mg/L	AF	1.8
TDS ,	1000 mg/L	-12.1	

SI = 7.5 + 0.5 + 1.3 + 1.8 - 12.1 = -1.0

When the saturation index is a NEGATIVE value - as in example 4 - the water is unsaturated and it will etch the marblesheen finish of the pool's interior, however, it is quite satisfactory in a fibreglass or a vinyl-lined pool.

TABLE 1
SATURATION INDEX = pH + TF + HF + AF -12.1
pH, ACTUAL READING
TF, TEMPERATURE FACTOR
HF, CALCIUM HARDNESS FACTOR
AF, TOTAL ALKALINITY FACTOR

TEMP. C°	TF	CALCIUM HARDNESS EXPRESSED AS mg/L CaCO3	HF	TOTAL ALKALINITY EXPRESSED AS mg/L CaCO3	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

It was pointed out earlier that one of the roles of the chemical treatment is to make the water compatible with the pool's finish, fittings and equipment. Also, it was mentioned that different pool finishes require different treatments.

It was also stated that the water which is out of chemical balance etched the marblesheen finish or it formed a deposit on it. In other words, the WATER REACTED with the marblesheen interior.

In the case of the vinyl lined pool, however, such etching is impossible by the unsaturated water as there is no plaster to etch and the vinyl is insoluble in the water.

Also it is difficult to form a hard scale on the smooth surface of the vinyl lining. In other words there was NO REACTION between the water and the vinyl lining. In the case of the over-saturation the excess is not held by the water and it is likely to become 'milky" and difficult or impossible to clear up by filtration. This situation may also apply to moulded fiberglass pools.

The pool finishes can be classified into two categories:

REACTIVE FINISHES like marblesheen, exposed aggregate, the grouting around the tiles, slates etc.

INERT FINISHES like vinyl lining, paint, fibreglass, any kind that does not contain cement or plaster.

NOTE: *If there are a couple of rows of tiles at the water line of a fibreglass pool with cement-based grouting between the tiles, the water should be treated as if the pool were fully tiled i.e. the pool's interior should be judged by its weakest point (the grouting, not the tiles) where the unbalanced water may cause damage.*

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The following saturation index values are recommended:

For REACTIVE FINISHES - SI + 0.2

If the water is heated then SI closer to -0.2 than to 0.2.

For instance:

calcium hardness 150 mg/L
total alkalinity 120 mg/L
pH 7.7

For INERT FINISHES = SI always below 0. When heated - SI always below -0.5.

For instance:

calcium hardness 50 mg/L
total alkalinity 80 mg/L
pH 7.4

HOW TO ALTER THE CHEMICAL BALANCE

CALCIUM HARDNESS

The correct level should be maintained in pools with reactive finish, i.e. marblesheen, etc. In new pools 250 – 350 mg/L is recommended to help maturing of the surface. In established pools about 150 mg/L is satisfactory.

There is no anti-destructive need for any calcium hardness in water which is in pools with inert finish, except to stabilize the pH and stop rapid changes which may cause interior surface damage.

How to increase the calcium hardness of pool water.

Calcium chloride or gypsum (calcium sulphate) may be used.

As calcium sulphates are not containing as much calcium as calcium carbonate a different factor should be used when the required quantities are calculated. The factors are: calcium chloride - 1.5 Calcium sulphate - 1.7.

Example

Calcium hardness of water: 50 mg/L
Calcium hardness required: 150 mg/L
Volume of pool: 50,000 L
Calcium chloride is used
(150-50)X1.5x50,000 = 7.5 Kg calcium chloride
1,000,000

How to lower the calcium hardness of the pool water.

This is a difficult process and it should be attempted if there are no alternatives, like replacing part of the water with softer water.

Example

The calcium hardness is to be reduced by 100 mg/L
Volume of pool: 60,000 L
Activity factor for tri-sodium phosphate: 2.5
100X2.5X60,000 = 15 kg tri-sodium phosphate
1,000,000

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Procedure

1. Add 500 g soda ash for each 10,000 L of pool water (3kg in this example). Mix it in well.
2. Add the calculated amount of tri-sodium phosphate (15 kg in this example). Mix it in well.
3. Allow the solids to settle overnight.
4. When the solids settled vacuum to waste
5. Restore the chemical balance as required.

TOTAL ALKALINITY

It is easy to increase or decrease the level of total alkalinity and it is recommended that this is used when adjustments are made to achieve the desirable saturation index. The total alkalinity must be established with sodium bicarbonate.

Soda ash is not switchable and it should not be used for this purpose.

The pH of the water will vary according to the concentration of the sodium bicarbonate.
The higher the total alkalinity the higher the pH is.

Also the pH is more stable when the total alkalinity is above 100 mg/L.

The approximate pH values –vs- total alkalinity are listed below:

Total Alkalinity - mg/L	pH
20	7.0
50	7.4
100	7.7
125	7.8
160	7.9
200	8.0

How to increase the total alkalinity of the pool water:

Sodium bicarbonate should be used and the factor of 1.7 is required in the calculations.

Example

Total alkalinity of water: 50 mg/L
Total alkalinity required: 100 mg/L
Volume of pool: 40,000 L
(100-50)X1.7x40,000 = 3.4 kg sodium bicarbonate
1,000,000

How to lower the total alkalinity of the pool water:

Hydrochloric acid or dry acid (sodium bisulphate) is used. The following factors apply:
Hydrochloric acid 2.0, dry acid 2.4.

Example

Total alkalinity of water: 150 mg/L
Total alkalinity required: 100 mg/L
Volume of pool: 75,000 L
Hydrochloric acid is used
(150-100) x 2X75,000 = 7.5 L hydrochloric acid required
1,000,000

NOTE: After adding the acid to the water the pH will be lower than expected, however, the final pH will be reached within a few days.

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pH

The value of the pH is dependant on the amounts of acidic or alkaline chemicals present in the water.

It cannot be altered without changing the acidity or the total alkalinity.
Irrespective of the pool's finish the pH of the water should be maintained above 7 at all times.

The only exception to this rule is in the case of ***older fibreglass pools*** which, due to osmosis, develop those unsightly black spots.

The recommended pH in that case is about 6.8.

When the pH of the pool water is below 7:

- the water is corrosive to metals, like the pump, railing etc.;
- the reactive interior, like marblesheen, grouting, will be etched;
- dissolves many of the metallic contaminates, like iron, copper etc. which should be filtered out. These contaminates will discolour the water or the wall as soon as the water becomes alkaline;
- the irritating chloramine formation is favoured;
- phenol red pH indicator solution does not indicate the correct pH below 6.8;
- water is clear as the acidity dissolves the scale and milkiness-forming calcium compounds;

When the pH of the pool water is 7.0.

- the pH changes rapidly as even small amounts of acids or alkaline materials cause significant changes;
- the colour and clarity of the water changes with the pH.

When the pH of the pool water is between 7.2 and 8.0

- this is the recommended pH range for all pools;
- as the total alkalinity increases the pH becomes more stable and predictable;
- chlorine and bromine sanitisers are effective and lasting;
- people can stay in the water for long periods without any sign of discomfort.

When the pH of the pool water is above 8.0.

- chlorine is ineffective with the increasing pH and much higher levels are required to maintain efficient sanitisation;
- the likelihood of "milkiness" and scale formation increases especially above pH 8.4;
- the water depletes the skin of the natural oils, especially in the warmer waters.

When the pH has to be altered it is carried out by increasing or decreasing the total alkalinity.

TOTAL DISSOLVED SOLIDS

As it was mentioned earlier the dissolved solids cannot be filtered out and they can be reduced only by discharging some or all of the water and replacing it by low TDS-containing water.

STARTING-UP PROCEDURE

1. Fill the pool to the operating level with water.

2. Add calcium or sodium hypochlorite to achieve 10 mg/L free chlorine and mix the water thoroughly. (800 g cal-hypo/50,000 L or 4 L liquid chlorine/50,000 L)

3. Add calcium chloride or sulphate, if required, or salt if it is used. Ensure that all the chemicals are dissolved and mixed in thoroughly.

4. If the pool water is cloudy flocculate the suspended solids and allow to settle.

5. Next day vacuum out the sediment. When the water is clear adjust the total alkalinity with sodium bicarbonate as required.

6. The cyanuric acid stabilizer may be added at this point.

7. Check the free chlorine level. If it is less than 1 mg/L in an unstabilized pool, or if it is less than 2 mg/L in a stabilized pool, then add the daily dose of chlorinating compound of the customer's choice.

8. The pool is ready to use.

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