Use of the Langelier Index to Balance Pool Water

General

A. In swimming pool waters, calcium bicarbonate is very soluble. When it breaks down it forms the insoluble calcium carbonate, the chief scale former. Scale generally appears as white or lightly colored rough blotches on pool walls. It also adheres to other objects in the pool. Calcium carbonate scale in the piping and filter system can restrict water flow and cause calcification of the filter bed, thus reducing filtration efficiency and shortening filter runs.

B. Scale deposits are usually caused by the presence of excess calcium and magnesium in pool water. These minerals become insoluble and can form scale. The factors which influence the formation of scale are:

1. Calcium hardness.
2. Total alkalinity.
3. pH level.
4. Water temperature.
5. Total dissolved solids.

Preventing scale-forming tendencies

A. These five factors can be given numerical values and applied to a formula known as the Langelier Index or Saturation Index. The formula, indicates whether a particular water has scale-forming or corrosive tendencies and what can be done to correct this condition. In the Langelier table below, numerical values are given for three of the five factors. An average factor for total solids is included in the formula. Using figures from the table and the following simplified version of the Langelier formula, the proper alkalinity balance of a pool's water--and hence its ability to resist scale-forming or corrosive tendencies--can be obtained.

Saturation Index = pH+TF+CF+AF-12.1
pH, actual reading
TF, temperature factor
CF, calcium hardness factor
AF, total alkalinity factor

B. For example:

1. If the Saturation Index is 0, the water is chemically in balance.

2. If the Index is a minus quantity, corrosive tendencies are indicated.

3. If the Index is a plus quantity, scale-forming tendencies are indicated. The Saturation Index is considered satisfactory in a swimming pool if the value is between plus one-half and minus one-half.

C. The Saturation Index is considered satisfactory in a swimming pool if the value is between plus one-half (+0.5) and minus one-half (-0.5).

TABLE K-1. Numerical Values for Langelier Formula

Temp			Calcium Hardness Expressed as:		Total Alkalinity Expressed as:	
C	**F**	**TF**	**ppm CaCO3**	**CF**	**ppm CaCO3**	**AF**
0	32	0.0	5	0.3	5	0.7
3	37	0.1	25	1.0	25	1.4
8	46	0.2	50	1.3	50	1.7
12	53	0.3	75	1.5	75	1.9
16	60	0.4	100	1.6	100	2.0
19	66	0.5	150	1.8	150	2.2
24	76	0.6	200	1.9	200	2.3
29	84	0.7	300	2.1	300	2.5
34	94	0.8	400	2.2	400	2.6
40	105	0.9	800	2.5	800	2.9
53	128	1.0	1,000	2.6	1,000	3.0

Examples

The following examples show how to use the SI to determine appropriate adjustment of pool water.

a. This example illustrates a pool with soft water having low temperature, low alkalinity and low hardness:

pH, 7.2
Calcium hardness, 5 ppm
Total alkalinity, 5 ppm
TF=0.3
CF=0.3
AF=0.7
Saturation Index=7.2+0.3+0.3+ 0.7-12.1=-3.6
Corrective action: This high negative Saturation Index of -3.6 shows an extreme corrosive condition.

(1) To correct it, sodium bicarbonate (baking soda), $NaHCO_3$, which has a mild effect on pH, can be added to increase the alkalinity to about 100 ppm (1.5 lb sodium bicarbonate per 10,000 gal (87 g/kL) of water will raise the alkalinity by 10 ppm.)

(2) To correct the problem of low water hardness, a chemical such as calcium chloride, $CaCl_2$, can be added to increase the hardness level to a minimum of about 100 ppm.(1 lb $CaCl_2$ per 10,000 gal (58 g/kL) of water will raise the calcium hardness about 11 ppm.)

(3) The water temperature can also be increased to more comfortable level of about 70°F (21°C).

(4) Finally, if required, adjust the pH to the desired 7.2 to 7.6 range. With the adjusted condition, the pool water should now be in balance, as shown below in the Saturation Index.

pH, 7.6
Temperature, 70°F (21°C)
Calcium hardness, 100 ppm
Total alkalinity, 100 ppm
TF =0.5
CF=1.6
AF=2.0
Saturation Index=7.6+0.5+1.6+ 2.0-12.1=-0.4

b. This example illustrates a pool with both hard and highly alkaline water.
pH, 8.5
Temperature, 84°F (29°C)
Calcium hardness, 800 ppm
Total alkalinity, 400 ppm
TF=0.7
CF=2.5

AF=2.6
Saturation Index=8.5+0.7+2.5+ 2.6-12.1=+2.2
Corrective action: This positive Saturation Index of +2.2 shows extreme tendency to form scale.
(1) The first factors to consider in correcting this condition are pH and total alkalinity, since they can be adjusted most readily.
(2) To correct this, muriatic acid, HCl, or sodium bisulfate, $NaHSO_4$, is added daily to lower the pH and total alkalinity to about 75 ppm.
(3) Add 1.5 pints Muriatic Acid per 10,000 gallons (19 mL/kL) of water to lower alkalinity 10 mg/l. The pool water is now in balance, as shown by the near zero Saturation Index:
pH, 7.4
Temperature, 84°F (29°C)
Calcium hardness, 800 ppm
Total alkalinity, 75 ppm
TF=0.7
CF=2.5
AF=1.9
Saturation Index=7.4+0.7+2.5+ 1.9-12.1=+0.4

c. The next example illustrates a pool with balanced water:
pH, 7.6
Temperature, 76°F (24°C)
Calcium hardness, 400 ppm
Total alkalinity, 50 ppm
TF=0.6
CF=2.2
AF=1.7
This shows a balanced condition. This example also demonstrates that with a pH of 7.6, a total alkalinity of 50 ppm and a temperature of 76°F (24°C), the Saturation Index is at a satisfactory value despite a calcium hardness range of 150 ppm (CF=1.8) to 1,000 ppm (CF=2.6):
Saturation Index=7.6+0.6+1.8+ 1.7-12.1=-0.4
Saturation Index=7.6+0.6+2.6+ 1.7-12.1=+0.4
Maintaining total alkalinity at 50 to 100 ppm and pH range from 7.2 to 7.6 has four benefits.
(1) Residual available chlorine does a more efficient job of controlling bacteria and algae.
(2) Scale formation is minimized.
(3) Scaling of heater coils is reduced to a minimum.
(4) Any pool problem due to chemical unbalance is eliminated.

In summary: Keeping pool water in balance

Unlike the Hamilton Index™, with the Langelier Saturation Index formula, a change in pH of a given value will change the index by a like amount. The most direct method of lowering pH is to add a common acid material such as muriatic acid, HCl. This not only lowers pH, but also reduces total alkalinity. The pH of the water should not be allowed to drop below 7.2. Actually, during normal treatment of pool water most chemicals used have some effect on scale formation. Chlorine gas, muriatic acid and other acid materials tend to reduce formation of scale while hypochlorites, soda ash and caustic soda tend to favor its formation. By keeping track of the chemicals added to a pool and by controlling pH (by far the simplest of the factors to measure and control) the pool operator can learn to keep the water in proper balance.