

Langelier Saturation Index

The Langelier Saturation Index (LI), a measure of a solution's ability to dissolve or deposit calcium carbonate, is often used as an indicator of the corrosivity of water. The index is not related directly to corrosion, but is related to the deposition of a calcium carbonate film or scale; this covering can insulate pipes, boilers, and other components of a system from contact with water. When no protective scale is formed, water is considered to be aggressive, and corrosion can occur. Highly corrosive water can cause system failures or result in health problems because of dissolved lead and other heavy metals. An excess of scale can also damage water systems, necessitating repair or replacement.

In developing the LI, Langelier derived an equation for the pH at which water is saturated with calcium carbonate (pH_s). This equation is based on the equilibrium expressions for calcium carbonate solubility and bicarbonate dissociation. To approximate actual conditions more closely, pH_s calculations were modified to include the effects of temperature and ionic strength.

The Langelier Index is defined as the difference between actual pH (measured) and calculated pH_s . The magnitude and sign of the LI value show water's tendency to form or dissolve scale, and thus to inhibit or encourage corrosion.

Although information obtained from the LI is not quantitative, it can be useful in estimating water treatment requirements for low pressure boilers, cooling towers, and water treatment plants, as well as serving as a general indicator of the corrosivity of water.

Parameter Measurement

The Langelier Saturation Index can be calculated easily by using Hach products to determine the pH of calcium carbonate saturation (pH) and the actual pH of a solution. Using a simple formula, the pH is derived from the values for calcium hardness, total alkalinity at pH 4.5, temperature, and total filterable residue (total dissolved solids). All of these procedures are included in this manual.

Temperature:

Temperature can be measured in degrees celsius with a laboratory thermometer (Cat. No. 566-01). If only a Fahrenheit thermometer is available, conversion to degrees Celsius will be necessary.

[$^{\circ}\text{C} = 5/9 \times (^{\circ}\text{F} - 32)$].

Calculation

After the preceding parameters have been determined, calculate the pH from the following formula:

$$\text{pH}_s = A + B - C - D$$

Where:

Constant A takes into account the effect of temperature. It is found by selecting the value from *Table 1* on page 3 that corresponds to the measured temperature in degrees Celsius.

Constant B is a correction for the ionic strength of the sample. It is determined using *Table 2* on page 4 by taking the value that corresponds to the measured total filterable residue or the estimated total dissolved solids (TDS).

Value C is obtained from *Table 3* on page 4 by reading the value corresponding to the calcium hardness (in mg/L CaCO₃) of the sample.

Value D is obtained from *Table 3* by reading the measured value for total alkalinity (in mg/L CaCO₃) of the sample.

The Langelier Saturation Index is the difference between the actual pH of the solution and pH_s calculated above.

$$LI = pH_{\text{actual}} - pH_s$$

Interpretation

The LI is a gauge of whether a water will precipitate or dissolve calcium carbonate. If the pH_s is equal to the actual pH, the water is considered “balanced”. This means that calcium carbonate will not be dissolved or precipitated. If the pH_s is less than the actual pH (the LI is a positive number), the water will tend to deposit calcium carbonate and is scale-forming (nonaggressive). If the pH_s is greater than the actual pH (the LI is a negative number), the water is not saturated and will dissolve calcium carbonate (aggressive). In summary:

pH_s = pH_{actual}, water is balanced

pH_s < pH_{actual}, water is scale forming (nonaggressive)

pH_s > pH_{actual}, water is not scale forming (aggressive)

It is important to remember that the LI value is not a quantitative measure of calcium carbonate saturation or corrosion.

Because the protective scale formation is dependent on pH, bicarbonate ion, calcium carbonate, dissolved solids, and temperature; each may affect the water's corrosive tendencies independently. Soft, low-alkalinity waters with either low or excessively high pH are corrosive, even though this may not be predicted by the LI. This is because insufficient amounts of calcium carbonate and alkalinity are available to form a protective scale.

Waters with high pH values and sufficient hardness and alkalinity may also be corrosive, even if the LI predicts the opposite. This is the result of calcium and magnesium complexes that cannot actively participate in the scale forming process. Analytical procedures do not distinguish between these complexes and available calcium and magnesium; therefore, the LI value is not accurate in such situations.

Corrosive tendencies may also be exhibited by water containing high concentrations of sulfate, chloride, and other ions which interfere with uniform carbonate film formation.

As a result of these and other problems, the LI is useful only for determining the corrosivity of waters containing more than 40 mg/L of alkalinity, sufficient calcium ion concentration, and ranging between pH 6.5 and 9.5.

Aggressive Index

The Aggressive Index (AI), originally developed for monitoring water in asbestos pipe, is sometimes substituted for the Langelier Index as an indicator of the corrosivity of water. The AI is derived from the actual pH, calcium hardness, and total alkalinity. (Use procedures contained in this handbook). Where it is applicable, it is simpler and more convenient than the LI. Because the AI does not include the effects of temperature or dissolved solids, it is less accurate as an analytical tool than the LI.

Calculation

After obtaining the pH, total alkalinity, and calcium hardness, use the following formula to calculate the AI:

$$AI = pH_{\text{actual}} + C + D$$

Where:

Value C is obtained from *Table 3* on page 4 by reading the value corresponding to the calcium hardness (in mg/L CaCO₃) of the sample.

Value D is obtained from *Table 3* by reading the measured value for total alkalinity (in mg/L CaCO₃) of the sample.

Interpretation

As with LI, the AI is not a quantitative measure of corrosion, but is a general indicator of the tendency for corrosion to occur, and as such, should be used with proper reservation. An AI of 12 or above indicates nonaggressive (not corrosive) water. AI values below 10 indicate extremely aggressive (corrosive) conditions. Values of 10–11.9 suggest that the water is moderately aggressive. Corrosivity characteristics of water as indicated by the LI and AI are compared in *Table 4* on page 4.

Table 1

Water Temperature, °C	A
0	2.60
4	2.50
8	2.40
12	2.30
16	2.20
20	2.10
25	2.00
30	1.90
40	1.70
50	1.55
60	1.40
70	1.25
80	1.15

Table 2

TDS, mg/L	B
0	9.70
100	9.77
200	9.83
400	9.86
600	9.89
1000	9.90

Table 3

Calcium Hardness or Total Alkalinity in mg/L CaCO ₃	C* or D**
10	1.00
20	1.30
30	1.48
40	1.60
50	1.70
60	1.78
70	1.84
80	1.90
100	2.00
200	2.30
300	2.48
400	2.60
500	2.70
600	2.78
700	2.84
800	2.90
900	2.95
1000	3.00

* Factor C is the logarithm (base 10) of the calcium hardness expressed in mg/L

** Factor D is the logarithm (base 10) of the total alkalinity expressed in mg/L

Table 4

Corrosive Characteristics	Langelier Index	Aggressive Index
Highly aggressive	< -2.0	< 10.0
Moderately aggressive	-2.0 to 0.0	10.00 to 12.0
Nonaggressive	>0.0	>12.0

References

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6. Robinson, R. A.; Stokes, R. H. Electrolyte Solutions 1965, Butterworth & Co. LTD: London.
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