

# Water Balance Indexes

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*Brought to you by the APSP Recreational Water Quality Committee*

## I. INTRODUCTION

There are several water balance indexes that are being used as tools to help predict whether pool water will deposit or dissolve calcium carbonate; or in other words, whether water tends toward scale forming or aggressive. These water balance indexes used by the swimming pool/spa industry are not guides for proper sanitizing or for human health and safety issues. Instead, they are an indication of calcium carbonate solubility and its effect on pool surfaces and equipment.

Maintaining proper pool/spa water balance (in addition to sanitizing) is important to help prevent calcium carbonate (scale) developing, or to prevent calcium from being removed (etched) from pool surfaces, particularly plaster/cement finishes.

These indexes include the Langelier Saturation Index, the Ryznar Stability Index, and the Hamilton Index. They are known as “Saturation Indexes.” This fact sheet will address the scientific principles and formulas, the limitations, application, and the similarities and differences between these Indexes.

## II. GENERAL DESCRIPTION

### LANGELIER SATURATION INDEX

The Langelier Saturation Index (LSI) was developed by W. F. Langelier in 1936 to predict the tendencies of a water to precipitate or dissolve calcium carbonate. The LSI is based on a theoretical principle taking into account the pH, temperature, total dissolved solids, bicarbonate and carbonate alkalinity, and calcium hardness of a given water, and establishes the pH at which the saturation of calcium carbonate occurs ( $pH_s$ ). The LSI number is equal to the actual pH minus  $pH_s$ .

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Langelier's original formula was revised and modified by Larson and Buswell, and by Van Waters & Rogers in 1964. The familiar equation used by the pool industry for years is as follows:  $LSI = pH + CF + AF - TF - 12.1$  [where F stands for a "factor" based on the base 10 logarithm – sometimes slightly adjusted – of the calcium hardness (CF), carbonate-species alkalinity (AF) and temperature (TF), with 12.1 being a Log-derived "constant" based on a TDS value of approximately 500 ppm.]

The LSI formula has again been updated and improved by taking into account higher total dissolved solids content found in many swimming pools, and isolating carbonate alkalinity from cyanurate alkalinity (Wojtowicz, 1998). Today, this modified version of the LSI is used by some in the pool industry, often referred to as simply the Saturation Index (SI).

According to the LSI:

- When the LSI is zero, the water is considered to be balanced. Calcium carbonate scale should not form, nor should calcium be dissolved from cementitious surfaces.
- When the LSI is above zero, the water is considered potentially scale forming. The higher the number, the stronger the tendency is for calcium carbonate scale to form.
- When the LSI is below zero, or a negative number, the water is considered potentially aggressive towards calcium/cementitious materials. The lower the number, the stronger the tendency is for etching to occur. Aggressive water may also be corrosive to metal surfaces.
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The minimum and maximum LSI for proper pool water balance is considered by the APSP to be -0.3 to +0.5. Ideal water is considered to be 0.0 to +0.5. Within these parameters, water should be neither unduly aggressive nor scale forming.

## RYZNAR STABILITY INDEX

The Ryznar Stability Index (RSI), developed by J. W. Ryznar in 1944, is based on the same water parameters and saturation of calcium calculation as used by the LSI. However, Ryznar made a mathematical adjustment to the LSI in order to always achieve a positive index number ( $RSI =$

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$2\text{pH}_s - \text{pH}$ ). In addition, the RSI is mainly based on empirical observations of calcium scaling and the corrosion of metals in municipal water systems.

According to the RSI:

- Water is considered balanced and not corrosive nor excessively scale forming when the value is from 5.0 to 7.0. (Various targets are cited. Consult equipment manufacturer literature for recommendations.)
- When the RSI is above 7.0, the water is considered to be potentially corrosive.
- When the RSI is below 5.0, the water is considered to be potentially scale forming.

It would be logical that the recent modifications (Wojtowicz 1998) to the LSI should also apply to the RSI.

A comparison between the RSI and LSI for typical swimming pool/spa water parameters shows that maintaining a balanced RSI of 5.0 to 7.0 roughly corresponds to maintaining an LSI of about +0.4 to +0.8. Some heater and equipment manufacturers prefer the RSI because it provides greater protection against corrosion of metals.

### HAMILTON INDEX

The Hamilton Index is a guide developed by an experienced service tech through field service and research over a period of eleven years beginning in the 1960's. A chart is provided outlining the water chemistry parameters to follow.

There are several principles behind the concept of the Hamilton Index (HI). It somewhat correlates to the LSI, however, it has its own unique differences and recommendations. First, the HI chart recommends maintaining the pH between 7.8 and 8.2. Second, depending on the total hardness (not calcium) level, the total (not carbonate) alkalinity is then adjusted to a target level. The higher the total hardness of the water, the lower the recommended or target total alkalinity. The HI chart does not consider TDS, cyanurate content, or temperature in determining water balance.

A comparison between the Hamilton and Langelier Indexes for typical swimming pool/spa water parameters shows that adhering to the Hamilton Index Chart generally corresponds to maintaining an LSI of 0.0 to +0.5.

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## LIMITATIONS AND WHAT THESE INDEXES DO NOT PREDICT

It should be understood that these indexes, including the LSI, RSI, and HI, do not necessarily predict the corrosion of steel and other metals. Corrosion of metals is generally a function of pH and the concentration of anions (e.g. sulfates and chlorides) and oxidants which would need to be taken into account. There are corrosion indexes, such as the Riddick, Larson-Skold, Stiff-Davis, Casil, and Pisigan & Singley Indexes that are more applicable to (metal) corrosion issues. It is possible for non-scaling (aggressive) water to also be non-corrosive to metals. Conversely, it is possible for “scaling” water to also be “corrosive” to metals. Therefore, the saturation indexes are not completely reliable with respect to corrosion of metals. The LSI, RSI and HI measure a tendency, not the actual amount of scale precipitation that might form, or the potential amount of calcium dissolved from a plaster/cementitious surfaces.

Since water parameters are constantly changing, there is no steady state in saturation chemistry. Rather, the Indexes are predictive tools used to anticipate general tendencies in the one direction or the other. Water can have a very high LSI and still not experience calcium carbonate scaling. Water that contains sequestering agents can inhibit scaling tendencies. Additionally, these indexes are not designed to predict the potential of calcium sulfate scaling, which also can affect the solubility of calcium carbonate. Testing accuracy is important to obtain an accurate index number.

An index result is a “snapshot” of the characteristics of the water at the time the sample was obtained, not necessarily an indication of what has happened in the past or what will happen in the future. In fact, when looking at pool water after a scaling or aggressive event, it should be understood that once precipitation (deposition) or dissolution (etching) of calcium carbonate occurs, the LSI changes. When precipitation of calcium carbonate occurs, the index number lowers, when dissolution of calcium carbonate occurs, the index number rises.

There is some confusion regarding balanced water with the Ryznar Index. While it appears that water with a Ryznar Index of 5.0 to 7.0 has been established as balanced, Ryznar himself stated that an index from 7.0 to 7.5 may not form a protective layer of calcium carbonate on piping, indicating that in some cases, no scaling or corrosion may occur when the water is between these two values.

In this regard, it appears that the RSI focuses more on preventing corrosion of metal and piping. Water that does not form scale can be corrosive to metal, which may explain why that index is shifted toward preferring slightly scale-forming water (as established by the LSI). Laying down a thin layer of scale seeks to ensure that no corrosion of metal occurs. Common industry errors made when using the LSI or the RSI when calculating calcium saturation include the use of total hardness in place of calcium hardness, the use of total alkalinity instead of carbonate-species alkalinity, and the use of 12.1 as a constant rather than as a TDS variable. This last error is especially apparent in salt pools where TDS levels far exceed the 500 ppm represented by the 12.1 value. The Hamilton Index uses TOTAL hardness and TOTAL Alkalinity.

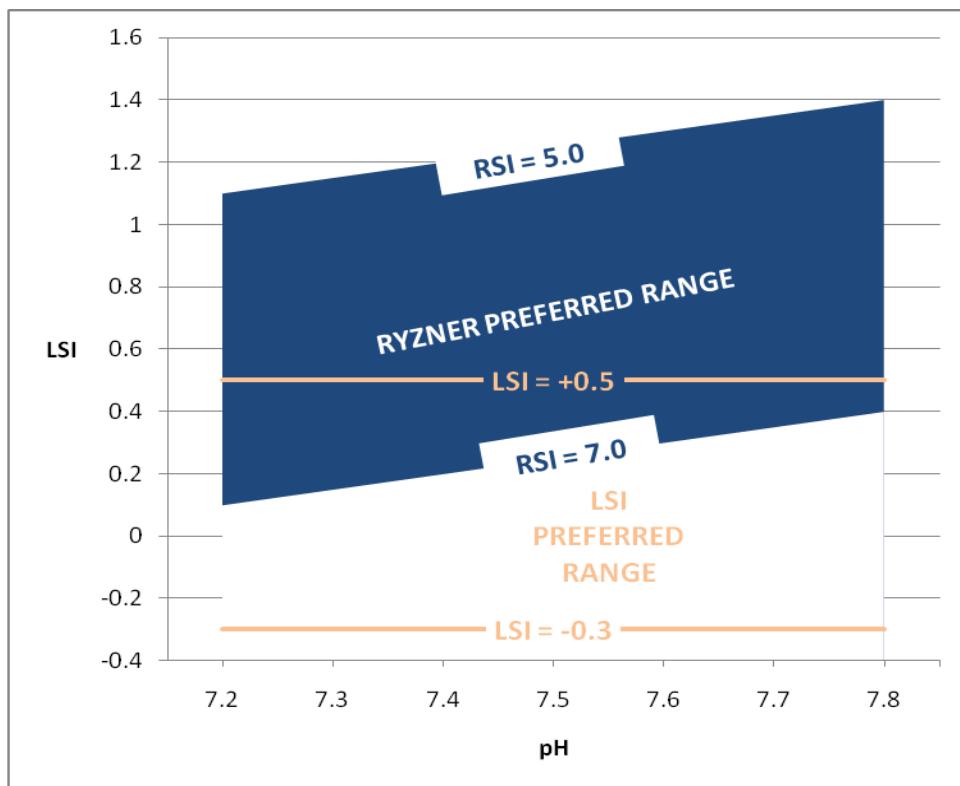


Figure 1. Comparison of Preferred Ranges in the Langelier and Ryzner Indexes

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### III. APPLICATION

See APSP-11 Appendix A for application of modified Langelier Saturation Index.

### IV. REFERENCES

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