



WATER BALANCE

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Overview

- LANGELIER SATURATION INDEX
- SCALING/CORROSION ISSUE
- WATER CLARITY ISSUE
- ADJUSTING WATER BALANCE

Section 1

LANGELIER SATURATION INDEX (SI)

What is SI?

- Water that has a lot of calcium wants to spit it out (scaling)
- Water that has little calcium wants more of it (etching)
- How much calcium comes out of or gets absorbed into water depends not only on calcium concentration but also on:
 - pH, temperature, alkalinity, and total dissolved solids
- SI is a method to determine whether the water will deposit or dissolve calcium

How is SI calculated?

$$SI = pH + Tf + Cf + Af - TDSf$$

Where,

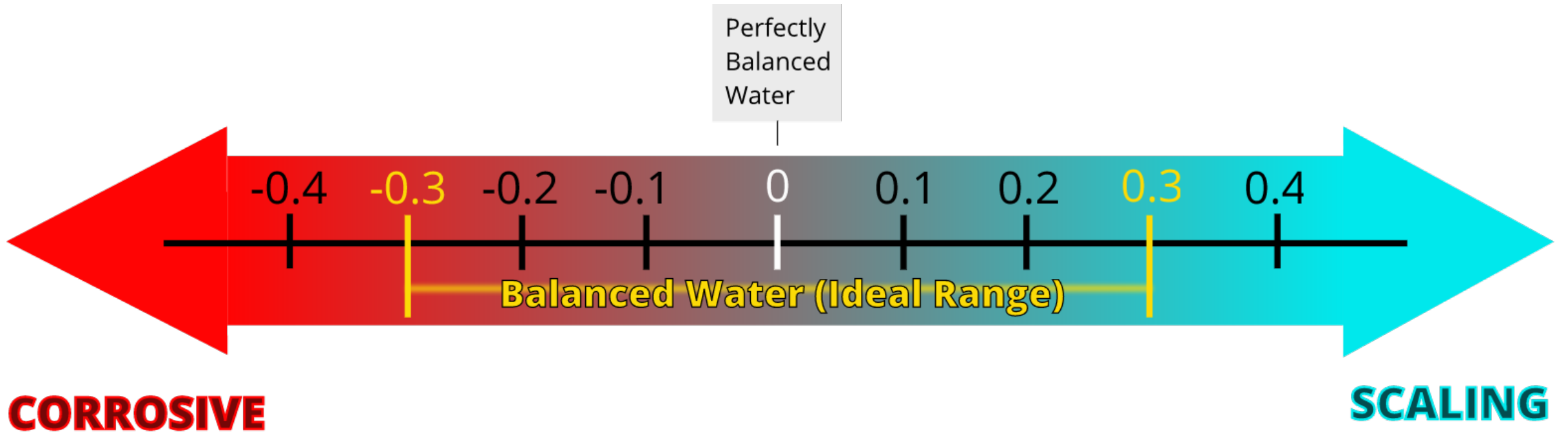
- pH is the pH test result reading
- Tf is Temperature Factor as in the table
- Cf is Calcium Factor as in the table
- Af is the Alkalinity Factor as in the table
- TDSf is Total Dissolved Solids Factor as in the table

Total Dissolved Solids Factors	
<1,000 ppm	>=1,000 ppm
12.1	12.2

Saturation Index Factors					
Temperature		Calcium Hardness		Total Alkalinity	
°F	Tf	ppm	Cf	ppm	Af
32	0.0	25	1.0	25	1.4
37	0.1	50	1.3	50	1.7
46	0.2	75	1.5	75	1.9
53	0.3	100	1.6	100	2.0
60	0.4	125	1.7	125	2.1
66	0.5	150	1.8	150	2.2
76	0.6	200	1.9	200	2.3
84	0.7	250	2.0	250	2.4
94	0.8	300	2.1	300	2.5
105	0.9	400	2.2	400	2.6
		800	2.5	800	2.9

What is Total Dissolved Solids (TDS)?

- TDS is everything that's dissolved and present in the water.
- Examples of materials that contribute to TDS:
 - Sodium ion (Na^+), chloride ion (Cl^-), calcium ion (Ca^{2+}), carbonate ion (CO_3^{2-}), and lots more...
- Water from natural sources already has some TDS (30 ppm to 6,000 ppm) with a typical range of 50 ppm to 500 ppm
- It is said that TDS in pool should not exceed 1,500 ppm above the starting point
- A high TDS means that not much more can be dissolved in water
- TDS can be measured with test kits and test strips, but...



Ideal SI Range

$$SI = pH + Tf + Cf + Af - TDSf$$

Let's practice using the formula

$$SI = pH + Tf + Cf + Af - TDSf = 0.4 \quad (\text{Slightly Scaling})$$

When,

- pH = 7.7
- Temperature = 87°F
- Calcium hardness = 230 ppm
- Total alkalinity = 125 ppm
- TDS = 1,200 ppm

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Total Dissolved Solids Factors	
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Other ways to calculate SI

- Automatic chemical controller systems usually calculate it for you
- Test kit manufacturers may carry something like...



Section 2

SCALING / CORROSION ISSUE

Scaling Issue

- Scaling happens when $SI > 0.3$
- Scaling is more likely to happen if:
 - Source water contains a lot of calcium
 - Source water has a high alkalinity level
 - Source water pH is high
 - Cal hypo is the disinfectant used
 - Water temperature is high (on the heat exchanger and in spa)
 - Plaster is used for pool surface

Scaling Issue (Continued)

- **Typical problems caused by scaling:**
 - Rough pool surfaces and dirty grey look
 - Scum line formation
 - Reduced water flow
 - Calcification of filter media and heater element
 - Cloudy water
- **What can be done to correct it?**
 - Lower calcium level, alkalinity level, and pH
 - Drain pool and/or add acid (Balance the water using SI)
 - Lower temperature if it is an option

Corrosion Issue

- Corrosion happens when $SI < -0.3$
- Corrosion is more likely to happen if:
 - Source water has a low calcium level
 - Source water has low pH
 - Source water has a low alkalinity level
 - Trichlor (or chlorine gas) is the disinfectant used
 - Water temperature is low (cold plunge)
 - Plaster is used for pool surface
 - Metal parts are used

Corrosion Issue (Continued)

- **Typical problems caused by corrosion:**
 - Etching of pool surfaces
 - Metal parts slowly being eaten away
 - Stains on pool surfaces due to dissolved metal in water
- **What can be done to correct it?**
 - Raise calcium level, alkalinity level, and pH
 - Drain and refill the pool if TDS is high
 - Raise temperature if it is an option

Section 3

WATER CLARITY ISSUE

Importance of Water Clarity

- **Safety - Being able to see:**
 - A drowning victim in water
 - Other bathers in water
 - Pool structure underwater (steps, benches, floor)
 - Main drain covers
- **Health – Cloudy water may mean:**
 - Inadequate filtration
 - Inadequate disinfection

What Causes Cloudy Water and What can be Done?

Possible reasons for cloudy water:	What can be done to correct it:
Improper filtration	Operate, maintenance, and replace as recommended
Insufficient circulation or flow rate	Ensure return inlets and recirculation flow rate are as designed and approved
Poor water chemistry	Use LSI formula to balance Ensure proper disinfectant level
Microscopic particles in water	Use clarifiers (coagulants and flocculants)

Section 4

HOW TO CORRECT WATER BALANCE

Correcting Water Balance - Basics

- Understand source water characteristics
 - pH, calcium, alkalinity, TDS
- Know the type of disinfectant used
 - pH impact, calcium
- Know the types of pH adjustment chemicals used and what's available
 - Muriatic acid, CO₂, Sodium bisulfate, Sodium carbonate
- Take water temperature into consideration
- Take pool water surface material into consideration

Cautions when adding chemicals to balance water

Ensure that:

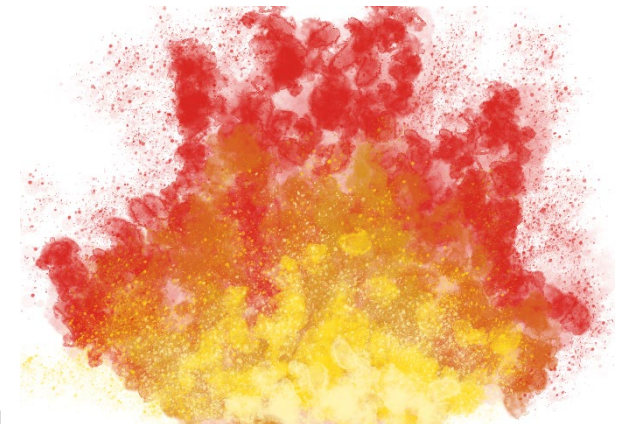
- There are no bathers in the water or on the deck (preferably no one in the facility)
- Ventilation functioning in indoor pools
- Operator has proper PPE
- Label may require that:
 - Chemical be diluted first before adding to the pool
 - **Always add chemical to a bucket of water (Not water to chemical)!**
 - **Use a tool to stir (Not your hand)!**
 - Chemical be broadcast directly from the package
 - **Watch out for wind!**
 - **Keep the package close to the water and away from your face!**

Mixing incompatible chemicals

- Acid and chlorine product (any chlorine-based disinfectant) will produce chlorine gas! More on this later.



- Acid is an oxidizer. Strong acid mixed with other chemical will produce heat!



Correcting Water Balance

- Water temperature is usually not a factor that can be changed, but if it is adjust it first
- First, adjust alkalinity if not in the desired range (80 to 120 ppm) already
- Second, adjust pH if not in the desired range (7.4 to 7.6) already
- Third, adjust calcium if there is not enough (150 ppm) already. If there is too much calcium (500 ppm to 1,000 ppm), water needs to be drained before anything else

Correcting Water Balance (Continued)

- Remember - Code has required ranges for:
 - Max temperature (104°F)
 - pH (7.2 to 8.0)
- But not for:
 - Alkalinity
 - Calcium hardness
 - Total dissolved solids
- It means that you have some flexibility

$$SI = pH + Tf + Cf + Af - TDSf$$

Adjusting Alkalinity

- First, be aware that 1/3 of CYA reading shows up as alkalinity. In other words, if you have high CYA, make sure to subtract 1/3 of that from alkalinity reading.
- In order to raise alkalinity, add sodium bicarbonate (baking soda)
 - Sodium bicarbonate is pH neutral
 - It contributes the following chemical species to pool water to increase alkalinity (CO_3^{2-} , HCO_3^- , OH^-)
- In order to reduce alkalinity, add muriatic acid or sodium bisulfate (not CO_2) **DANGER – never do this when bathers in pool**
- Always follow label instructions!



For each 10,000 gallons of water			
	Desired Increase		
Chemical used	10 ppm	30 ppm	50 ppm
Sodium bicarbonate	1.4 lbs	4.2 lbs	7.0 lbs
	Desired Decrease		
Chemical used	10 ppm	30 ppm	50 ppm
Muriatic acid (31.4% strength)	25 fl oz	2.4 qts	1 gal

Adjusting Calcium Hardness

- Know that calcium dissolves more in cold water
- Spa is more prone to scaling
- In order to raise calcium hardness, add calcium chloride
 - Calcium chloride is pH neutral when dilute
 - It contributes the following chemical species to pool water (Ca^{2+} , Cl^-)
- In order to reduce calcium hardness, drain the water
- Using water softener to treat make-up water can help keep calcium level in check
- Always follow label instructions!

For each 10,000 gallons of water			
	Desired Increase		
Chemical used	10 ppm	30 ppm	50 ppm
Calcium chloride (100 %)	0.9 lbs	2.8 lbs	4.6 lbs

Adjusting Total Dissolved Solids (?)

- You can't really adjust it
- Remember:
 - Source water already contains some TDS
 - TDS keeps building up as more and more chemicals are added to the pool
 - TDS level that's 1,500 ppm higher than the starting point is considered high
 - Only way to reduce TDS is to drain and refill

Questions for the 3rd Segment?



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