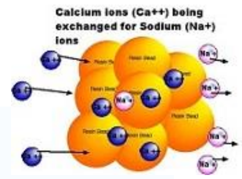
Water Technologies –Hard Water Lime Scale or CaC03 Water Hardness



Problems with hard water – Lime Scale Build Up and Scale Contamination.

Hard water is defined as water from a source, mainly well, or borehole water with *tested levels of dissolved & suspended magnesium and calcium ions, noted as CaC03 hardness, ranging from soft, low value mg/l or ppm to very high values in mg/l or ppm. See table below. * A source water sample is tested at a laboratory for CaCo3 hardness.

CLASSIFICATION	Hardness in mg/l or ppm
SOFT	0 - 60
MODERATLY HARD	61 - 120
HARD	121 - 180
VERY HARD	>180

The minimum test to be done and analytical report required, [a full spectrum chemical analysis is not required, but suggested], to #calculate the water softening di-ionizing system size & media loading is;

- Ca as calcium
- Mg as magnesium
- Na as sodium salts
- Fe as iron
- Mn as manganese
- CaC03 hardness

As a guide and for reference, see detail required for #calculating water softener size/capacity on pages 4 & 5.

The ions dissolve easily in water, and due to cohesion, they tend to stick together, or precipitate. They also tend to bond with other substances, such as copper.

When a few ions bond with such substances, other ions will, in turn, bond with them. These ions can cause problems with metal structures and heating equipment, geysers, heating elements etc.

The ions build up as deposits inside water pipes and water heaters, eventually clogging the pipes. In many households, commercial and agricultural, calcium or magnesium may build up in cookware, especially in coffee machines and kettles, referred to as lime scale.

The clusters of calcium and magnesium ions forms what could be described as "scale," or, more informally, "buildup." Additionally, when one showers or washes their hands in hot water, the ions react with the soap to form a sticky "scum," which hinders the soap's ability to lather properly.

To alleviate problems with hard water, it can be treated to reduce the calcium and magnesium concentration.

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Solutions are available, however, for households, commercial & industrial, the most cost effective, efficient and inexpensive solution is to use a water softener for bulk water supply.

So, let us start with what we know:

1. The first step is to remind ourselves what is the source of our nemesis, "hardness scale". Anyone who has been in the water treatment profession for any length of time is familiar with the hydrological cycle. Not to belabor the subject, but evaporating water creates water vapor that aggregates to form clouds, eventually resulting precipitation. While in the atmosphere, the water droplets absorb atmospheric gases including carbon dioxide which leads to the formation of carbonic acid. The rain or snow falling to the ground therefore consists of highly pure water (low TDS) containing carbonic acid (below neutral pH). As the water comes into contact with the various minerals of the earth's crust on its way to the ground water table, it leaches minerals from limestone deposits. In a nutshell, focusing on calcium and magnesium, limestone or dolomite – a solid consisting of calcium and magnesium carbonate – is forced into the dissolved form of calcium and magnesium bicarbonate and held there by the reductive power of carbonic acid.

2. The second reminder pertains to what scale actually is:
In essence scale is hardness that has precipitated out of a hydrous solution reverting to its solid form – in other words mineral crystals or plain old limestone. You may choose to call it scale – or the formation clusters of calcium carbonate crystals in undesirable locations.

An analogy would be horse manure versus horse excrement. What you call it depends on where you encounter it and how useful it is to your particular situation, i.e. whether you find it in the rose garden or on the threshold of your front door. The fact is, solid mineral salts are dissolved by rain or snow melt and return to their solid state when scale is formed.

3. Step three is spending a moment considering what you do know about whem and where scale actually forms: We know that the plumbing material does make a big difference; conductive materials like copper or galvanized pipe will accumulate scale much more readily than non-conductive plastics or poly plumbing. Galvanic activity is a hotspot for scale formation. Scale will form on rough surfaces more readily than smooth ones. It is also much more likely to occur in systems where water is heated versus in cold water lines. Also, one is more likely to see it where pressure drops or where turbulence occurs. The most important observation: scale is initially slow to form on plumbing surfaces, however, once it gets started it assumes an exponential growth curve! In other words, hardness likes to precipitate in the proximity of and add to the surface of existing scale.

Understanding how, why, where and when scale forms leads to understanding how to prevent it.

Dissolved hardness minerals and scale:

In the 1920s, the early years of central water systems, the East Bay Water Company had issues of scale forming in their municipal water distribution system. The utility hired Wilfred F. Langelier, professor for Civil Engineering at UC Berkeley teaching water chemistry, as a consultant to study the problem and find solutions. Years of research produced a formula capable of predicting corrosion and scaling in water systems: the Langelier Saturation Index was born. This basic formula has been refined some since then, but essentially it is still in use today. The operator of your local water plant or service person caring for your swimming pool may not have any idea who Mr. Langelier is, but both live by his discoveries every day. In essence, the Langelier Saturation Index (LSI) is a formula quantifying how several water chemistry parameters interact resulting in a positive or negative number predicting the likelihood of corrosion or scale precipitation occurring. A result of zero (0) implies perfect balance. The factors are pH (the higher the pH, the higher the likelihood of scale), temperature (higher = more scaling), hardness (higher = more scaling), alkalinity (higher = more scaling). A factor of +1 warns of scaling and a factor of -1 warns of corrosion.

The conclusion is that "hard" water is the battleground of two competing forces: the "desire" of the minerals to return to their solid form (lowest energy state) and the power of the carbonic acid forcing them to remain in solution. A shift of the balance in the direction towards lower saturation (more carbonic acid than required to keep the minerals in solution) results in a lower pH and water becomes aggressive or corrosive to existing scale deposits and - in the absence of scale crystals being able to buffer the pH drop by dissolving, corrosion of plumbing materials occurs. A shift towards higher saturation (less carbonic acid than required to keep minerals in solution) will result in precipitation of minerals and the formation of lime scale. It is a tug of war with a shifting balance largely determined by the amount of the carbonic acid present in the water. Water itself has a virtually non-existent ability to dissolve lime scale. Put another way: Water does not dissolve calcium carbonate! Carbonic acid does!

Now, we do know that in a closed system like a piping system hardness minerals and alkalinity cannot disappear. We can therefore contend that given a vessel would contain water and hardness minerals either in dissolved or precipitated (scale) form can be considered to have a constant mineral content. If the minerals and carbonic acid are in a state of equilibrium (saturation) you have neither scaling, nor corrosion. If there is more carbonic acid than needed to keep the minerals that are present in solution, you would have a low pH and a corrosive environment. Conversely, if you have more minerals than carbonic acid available to keep the minerals in solution, you would have a state of super-saturation and minerals would come out of solution and form scale. Since the mineral content is a constant, carbonic acid becomes the critical factor in scale formation and/or the absence thereof – and with carbonic acid we are getting into an area that is not as widely understood or at least as widely discussed as the previous points, but is the key to understanding the phenomenon.

Carbon Dioxide and Carbonic Acid:

We all know that carbonic acid is created when carbon dioxide is dissolved in water, however, most of us do not know that only a very small percentage averaging around one percent (1%) to zero point one seven percent (0.17%) at a water temperature of 25ºC (77ºF) actually ionizes to create the acid. The vast majority of the carbon dioxide remains present merely as a dissolved gas.

Here we have a total of three factors to consider:

1. Solubility of gases, particularly carbon dioxide, in water:
The most basic aspect to consider is the fact that the solubility of the gas CO2 in water varies greatly with temperature and pressure. Here also: the higher the temperature, the less CO2 will be able to go into solution with water. (When you observe water being heated the small bubbles forming in water prior to boiling are largely carbon dioxide gas coming out of solution.)
2. Equilibrium of CO2 gas and carbonic acid in water:
Furthermore, as stated above, carbon dioxide and carbonic acid are subject to being in "balance" with each other, i.e. a certain set of conditions will result in a certain percentage of the CO2 gas forming carbonic acid. A powerful factor in this balance is the dependency on

temperature: the higher the temperature, the lower the percentage of CO_2 actually forming carbonic acid. Other influences include state of agitation of the water, surface tension and the like. (A soda in a can that has been shaken prior to opening will act differently than one that has not.)

3. Reaction times:

At room temperature it takes 590 times longer for water and CO_2 to form carbonic acid than it does for carbonic acid to break down into water and CO_2 gas. Put another way, the destruction carbonic acid occurs 590 times faster than its formation.

Putting it all together - conclusion:

Physical – or non-chemical, di-ionization processes – for water treatment is a way of containing the symptoms, or effect of water hardness without using chemicals. IF high in sodium salts, need to consider Nano or reverse osmosis membrane technology.

INSTRUCTIONS FOR CALCULATING WATER SOFTENER SIZE/CAPACITY – WE WOULD NEED THE WATER TEST REPORT TO PROCEED

WHAT IS THE TOTAL WATER HARDNESS	Total hardness in mg/l or ppm divided by 17.1 = total hardness in GPG
THEN ADJUST FOR IRON	Add 4 grain hardness for 1 ppm of iron detected – round up -
THEN ADJUST FOR MANGANESE	Add 4 grain hardness for 1 ppm of manganese detected – round up
RESULT OF ABOVE	Is the adjusted TOTAL HARDNESS in GRAINS
MULTIPLY TOTAL LTS WATER USAGE PER DAY X ADJUSTED TOTAL HARDNESS	
MULTIPLY THIS NUMBER BY THE NUMBER OF DAYS DESIRED BETWEEN REGENERATION CYCLES	Max is 7 days
THIS WILL BE THE MINIMUM SOFTENER CAPACITY IN GRAINS NEEDED TO TREAT YOUR AVERAGE WATER DEMAND	

Will always use the minimum hardness capacity MHC of a softener – not the maximum capacity to gain a 40% salt saving advantage.

TYPICAL MINERAL TANK/VESSEL SIZE & TYPICAL MINIMUM HARDNESS CAPACITY [MHC]

VESSEL SIZE	LITRES	MHC	MAX CAPACITY[GCR] Grains Cap to Regen
9*48	28.316	20000 GRAINS	30000 GPR
10*54	42.474	30000	45000
12*52	56.632	40000	60000
14*65	84.948	60000	90000
16*65	113.264	90000	120000
18*65	169.89	120000	140000
21*62	198.212	140000	210000
24*72	283.160	210000	275000

Larger units required & as a DUPLEX system – quote on request

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Guide to offering a solution for lime scale treatment;

OFFERING PROCEDURE;

1. CLIENT MUST SUPPLY YOU WITH A RECENT LABORATORY WATER TEST REPORT/ANALYSIS – A FULL SPECTRUM SANS241 OR SIMILAR – OR THE MIN REQUIRED AS ON PAGE 1	If not available and unable to have the water tested locally/remote site – request a sample send to you via [a] courier [b] to be collected by a local representative. The sample to be delivered to TR Lab Services in Bartlett, Boksburg. Cost of full SANS241 analysis is current R2100.00 + VAT - Lab detail to supply. Often clients DO HAVE a water report.
2. ONCE HAVE THE REPORT/TEST/ANALYSIS – SEND TO NIMBUS WATER – ANDRE@NIMBUSWATER.CO.ZA TO PROCEED WITH THE ABOVE CALCULATIONS AND NIMBUS WILL FORWARD A QUOTE FOR THE SIZED SYSTEM.	Nimbus will need to also know what is the site daily water usage – estimate per day acceptable & advise if it is a 10, 12 or 24hr type operation.
AS A COST GUIDE – ALL SUBJECT TO THE CALCULATIONS AND SIZE & MEDIA LOADING, HOURS OF OPERATION & WATER USAGE	Range from R11,800.00 + VAT to > R100,000.00 PLUS, + VAT ex factory as a SIMPLEX or DUPLEX system, depends on the GCR.
INSTALLATION	To discuss
TYPICAL INSTALLATION OF A DUPLEX 18*65 SYSTEM AT VARSITY IN POTCH