

ECONOMICAL AND ENVIRONMENTAL SOLUTIONS

The Most Tough Undesired Components and Pollutants in Water Pipes

1. Scale and Water Hardness
2. Corrosion and Rust
3. Bacteria and Algae

Scale and Hard Water Problems

Water with higher content of alkali earth (Ca, Mg), bicarbonates is called hard water.

Recognizing hard water

- Hard water prevents soap from lathering by causing the development of an insoluble precipitate in the water.

Origin of ions that cause hardness in natural waters

- As ocean water evaporates, it forms clouds, which condense and precipitate rain.
- As rain water falls it encounters carbon dioxide and reacts with it to form a mild acid (Carbonic Acid).
- $\text{CO}_2 + \text{H}_2\text{O} = \text{H}_2\text{CO}_3$
- Thus as rain water comes into contact with limestone in the earth, the limestone dissolves and goes into solution with the water.
- $\text{CaCO}_3 + \text{H}_2\text{CO}_3 = \text{Ca} + 2 \text{HCO}_3$



- Surface waters also encounter carbon dioxide from the decay of organic materials. As these waters contact limestone, the limestone gradually dissolves and goes into solution.

How hard water is formed in nature

- When the concentration of calcium and bicarbonate increases due to the intensive reactions of rain water when it falls on carbonate rocks this may cause water hardness.

The main problem associated with the use of hard water in the different applications is scale

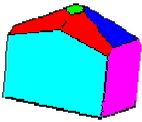
- Scale is a precipitate deposited on surfaces (e.g. inner pipe surfaces) that are in contact with water.
- Scale forms rocklike deposits inside and/or on water pipes and equipments.

The factors that affect the formation of Scale are:

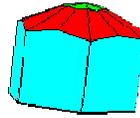
1. *The degree of super saturation (high saturation index enhances scale formation)* $\text{Ca}^{2+} + 2 \text{HCO}_3^- \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2$
2. *Temperature (increase temperature, decreases solubility of CaCO_3 and enhances scale formation)*
3. *PH (increase PH, decreases solubility of CaCO_3 and enhances scale formation)*
4. *Organic Processes*

CaCO₃ Crystal Forms

Orthorhombic Aragonite



Hexagonal Calcite



Lime-scale is only a problem if calcium carbonate precipitates as hexagonal calcite crystals.

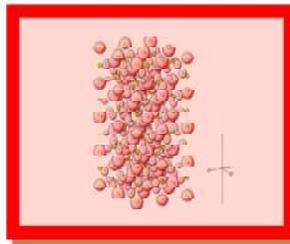
Orthorhombic aragonite crystals, *which are 19 times more soluble than calcite*, are less prone to form hard scale.

Very Important to know, *Calcite crystal seed needs a surface (the wall of the pipe) to precipitate upon but the Aragonite may nucleate in solution and form soluble substance which does not adhere to surfaces*

CaCO₃ Crystal Structures



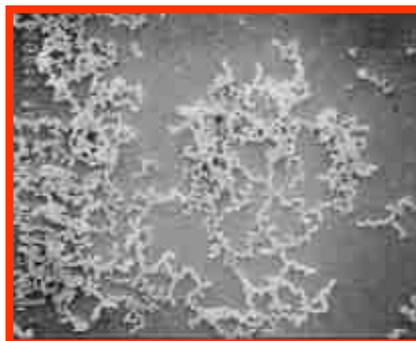
Aragonite



Calcite



A



B

Electron microscope photographs for water samples with (A) and without (B) scale **Magnification 2000x**

- It is common that calcium carbonate scale to adhere to the inner wall of the pipes. This causes the following problems in the pipe networks
1. **Reduction in the flow rate. This may require increased pressure to maintain the water flow.**
 2. **Reduction in the efficiency of heat exchangers**
 3. **Increasing the cost associated with operating systems using water conduits.**



2. Corrosion and Rust Problems

Corrosion

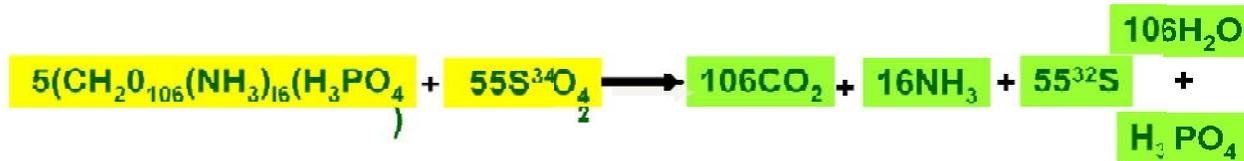
Corrosion is the result of some bacterial and/or chemical reactions inside pipes. Rust is a combination of trivalent iron with oxygen *i.e.* ferric oxide (Fe_2O_3).

Corrosion leads to biting the water pipes. This ends up to great maintenance costs



4. Bacteriological Problems

Sulfate Reducing Bacteria (SRB)



This kind of bacteria is catastrophic for pipe network via: *enhancing scale, poisoning water and causing pipe biting.*

- **Infectious bacteria, algae and viruses, these include pathogenic (disease producing) bacteria, viruses, algae and protozoan's (microorganisms).**
- **These organisms constitute a major problem for (pipe works) water delivery systems.**

Hydro Dynamic Magnetic Systems for Scale Removal and Prevention.

Innovative Scale Control Technology for Heat Exchangers, Boilers, Condensers, Chillers, Evaporators and cooling towers. Millions of dollars in extra fuel costs are wasted each year due to mineral scale deposit build-up.

These rock-hard deposits increase fuel costs, repair and maintenance expenditure and equipment down time. Excessive scale build-up can increase the possibility of pipe rapture, equipment failure and even explosions.

HDMR units are self powered by permanent magnetic field treating the fluid to prevent scale build-up and remove existing scale downstream, in both water pipes and fire tube boilers.

HDMR systems are compact; require no external power source and no maintenance. They have no moving parts, and can be custom built to virtually any size to meet the needs of any fluid process or operation.

Scale Build-up Costs Money

Scale thickness	Fuel Wasted	Money Wasted
1/8"	+25%	\$42,658
1/4"	+40%	\$68,110
1/2"	+70%	119,192

Annual extra fuel costs, based on a 500 HP boiler operating 10 hours per day, 260 days per annum; natural gas price based on \$3.15 per 1000 cubic feet (MMBTU).

Before



After 90 days



Fuel Costs Due to Boiler Scale:

Test Results by U.S. Bureau of Standards

Boiler Horsepower:		100 HP	200 HP	500 HP	1000 HP
Annual Fuel Cost, Clean Boiler (80% efficient)		\$34,055	\$68,110	\$170,275	\$340,550
Scale Thickness	% Extra Fuel Cost	Extra Cost:	Extra Cost:	Extra Cost:	Extra Cost:
1/8"	+ 25%	\$8,513	\$17,027	\$42,568	\$85,137
1/4"	+ 40%	\$13,622	\$27,244	\$68,110	\$136,220
1/2"	+ 70%	\$23,838	\$47,677	\$119,192	\$238,385

Annual extra fuel costs are based on a boiler operating 10 hours per day, 260 days per year. Natural Gas price is based on \$3.11 per 1000 cubic feet (MMBTU).

