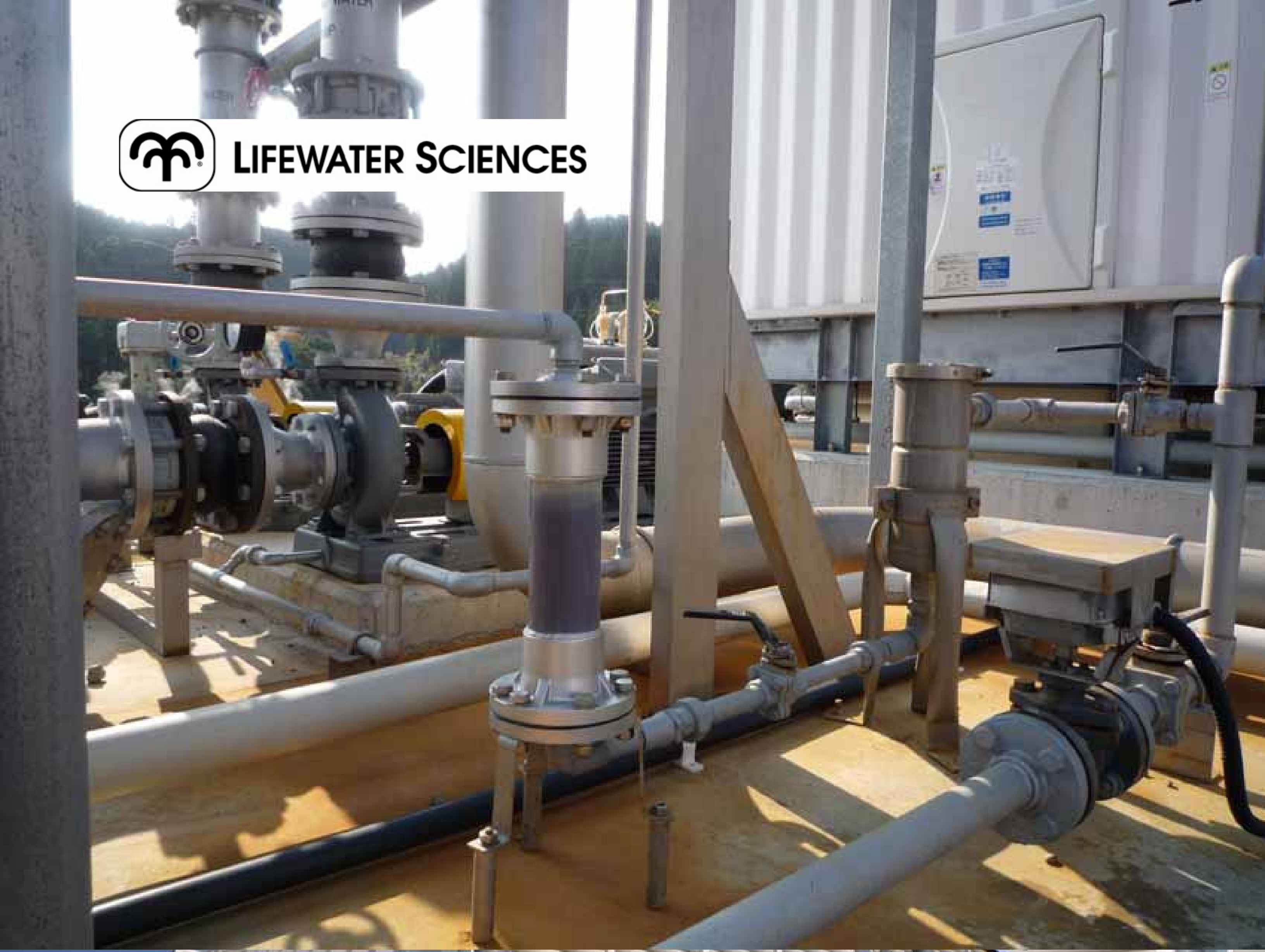
LIFEWATER SCIENCES



LifeWater Sciences WET (Water Enhancement Technology)

Scale Removal Device [SRD]

LifeWater Sciences WET.[SRD System–Cooling Tower

The Scale Removal Device (SRD)
For Water Cooling Tower

1. **Introduction.** In Cooling Tower operation the formation of scale, slime and algae are major concerns. Methods to control these contaminants include the use of chemicals and regularly draining the circulating water. A far better process is to use the Scale Removal Device (SRD).

By cat-ionizing the circulating water, treated water is able to absorb considerable amounts of CO_2 from the air. Ionized Ca, Si and Mg in the water combine with the absorbed CO_2 forming crystals of $CaCO_3$, $MgCO_3$ and SiO_2. These crystals, covered with cat-ionized membranes, float in the water in colloidal states. Since these colloids have the same charge, they never bind to one another nor attach to the inside surface of pipes or to the heat transmission surfaces of heat exchangers.

These colloidal crystals sink to the basin of a cooling tower and accumulate where the water flow is slow. Cat-ionized membranes covering the crystalline particles inhibit bonds of accumulated crystals; so that scales do not develop (The corrosion prevention mechanism for pipes is described on Page 5).

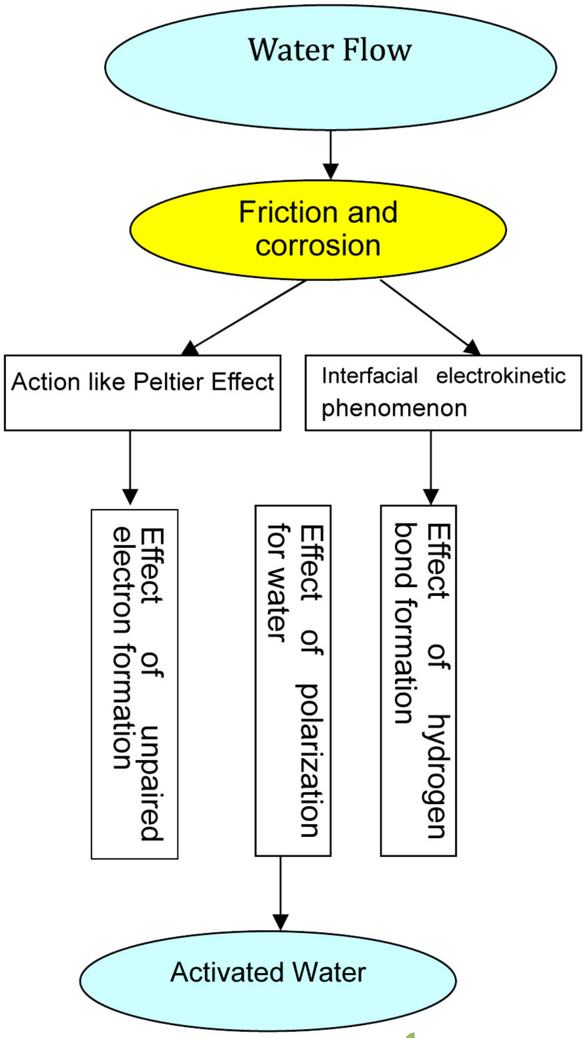
> *"The SRD, mounted to a cooling tower, prevents adhesion of rust and scales by circulating cat-ionized water, without the use of chemicals."*
>
> *Maintenance Manager Baxter Corporation-Japan*

2. **Cat-ion Charge.** Activating water by the SRD changes the water structure. With the positive charge acceptance by using weak electromagnetic, and thermoelectric conversion effects through electric double layer formation at the interface. This occurs through friction or collision between ceramic particles by water flow (like water springing from the sand) because of the SRD. We call this system "Interfacial electro kinetic phenomenon." The water activated by this system controls the formation and adhesive capability of scale, urinary calcification and slime deposits. This activated water also has increased detergent capabilities.

Interfacial electro-kinetic phenomenon. The electrical occurrence effect that generates at the interface between moving ceramics and flowing water in an electric double layer. The surface of the ceramics is always negatively charged. The water flow is always positively charged. In addition, the Peltier effect gives the water a more positively charged state.

The Peltier effect. A thermoelectric conversion generated in an interface of different kinds of metal with different temperature. When granular ceramics collide with each other, a temperature change occurs between the core and surface, that has a higher temperature. If the Peltier effect works, an electric current flows from the surface to the core of the silica ceramics. As a result, water activated, more positively charged.

Interaction with substances that have unpaired electron formation. Substances such as water (H2O), ammonia (NH3) and chlorine (Cl) have electron pairs that do not form a bond. They are generally represented by as in H-O-H, NH3, Cl these unpaired electrons are negatively charged and readily interact with positively charged, activated water. The interaction makes them bond with each other and lose their volatility. This explains why the activated water can eliminates toilet odor and the chlorine smells.

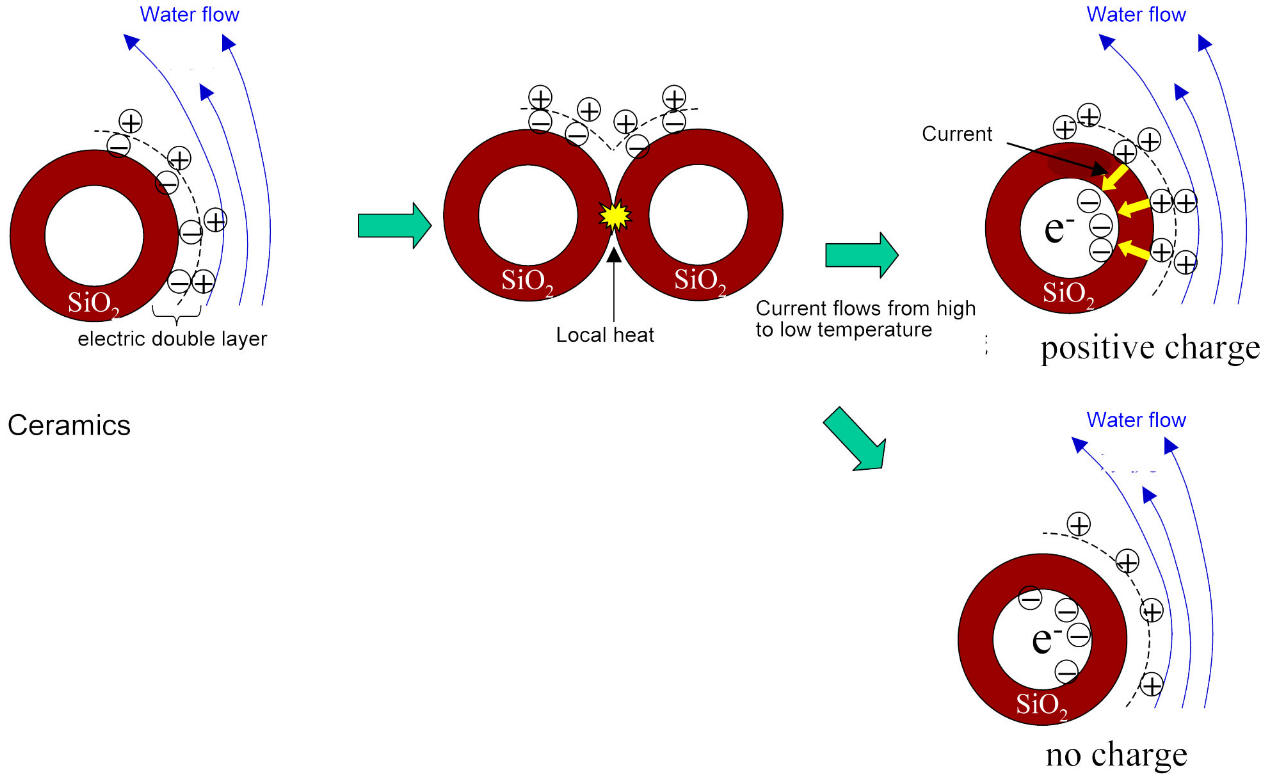


The system of interfacial electro-kinetic treatment

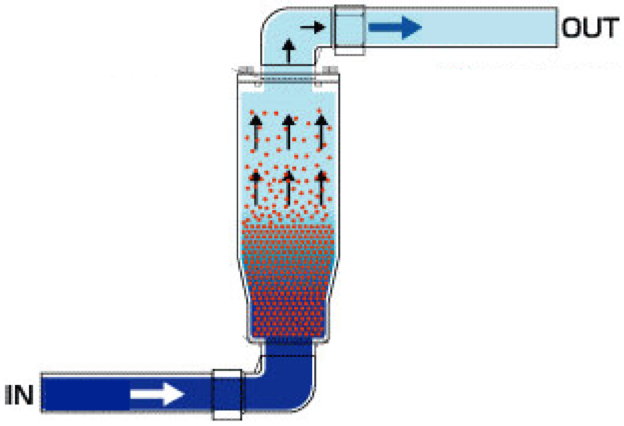
Effect of polarization for water. An oxygen atom has higher electro negativity than a hydrogen atom. Since each covalent bond is polar because of the unequal charge distribution of inter-atomic bonds, water molecules are also polarized. Polarization can be altered when the water is positively charged.

Effect of hydrogen bond formation. The polarity of water causes hydrogen bonds to occur between water molecules. As a result, the polarity of molecules and hydrogen bonds give the water a solvent property (liquid that dissolves other substances). Hydrogen bonding plays an important role in nature. It is a unique function of water, which is an essential liquid for all organisms.

The function of ceramics and the principle of interfacial electro kinetics the ceramic surface has negative zeta potential. It improves “the effect of polarization” and “hydrogen bond formation” in water. It also has the ability to increase “the interaction with the substances that have unpaired electron formation.”

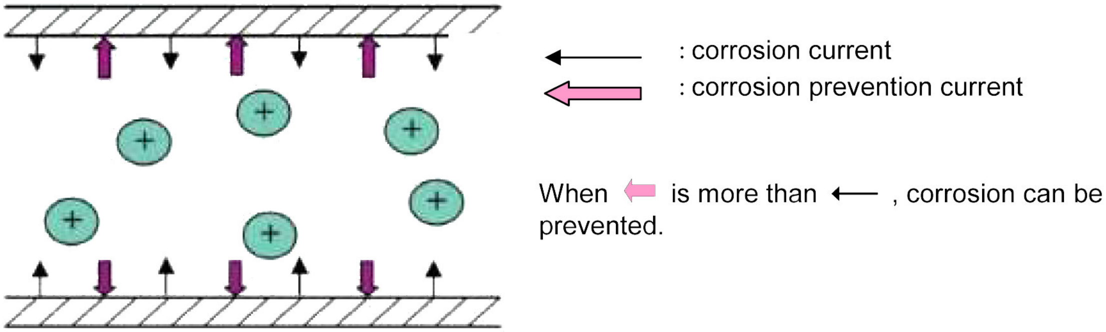


FLUIDIZATION AND ELECTRO-KINETIC EFFECT OF CERAMIC BALLS



3. **Theory of Corrosion Prevention.** Metal corrosion is generally considered to be an electrochemical reaction. Metal rusts when it loses electrons. In an environment where metal is exposed to water, numerous parts with dissimilar electric potentials are created on its surface. In other words, a cathode with a high potential and an anode with a low potential form a local cell. Dissolving in water as positive ions in an anode, metal combines with oxygen, and as a result, rusts. The range of electric potentials where this phenomenon occurs is called 'a corrosion range'.

The electric potential of iron is -440mV, which is within a corrosion range. Corrosion can be prevented, however, by giving the iron more electric potential to get it out of this range. In theory, the SRD cat-ionizes the water by ceramic collision and lowers the electric potential of iron to the potential range and consequently prevents rust.



When ⇐ is more than ← , corrosion can be prevented.

The degree of corrosion is influenced by various water conditions: water residence time in pipes, water temperature, and the concentration of pH, residual chlorine, and dissolved oxygen.

The water treated with the SRD increases osmotic force by electro kinetic phenomenon and act on loose rust in the following stages; penetration → swelling → decay → stripping.
It is also believed that black rust (Fe_3O_4 Ferrun Tetroxide) develops on the inside surface of pipes following the stripping stage and inhibits corrosion. Red rust (Fe_2O_3) exists in the water as $Fe(OH)_3$.

The treated water is reduced to $Fe(OH)_3$ as follows:

$$H^+ + O_2 + e^- \rightarrow HO_2$$
$$Fe(OH)_3 + HO_2 \rightarrow Fe(OH)_2 + H_2O + O_2$$

As red rust dissolves in activated water, reduced $Fe(OH)_2$ combines with $Fe(OH)_3$ and forms black rust(magnetite), or $Fe(OH)_8$, in the water.

$4H_2O + FeO_4$ （black rust in the air

$Fe(OH)_2 + 2Fe(OH)_3 \rightarrow Fe(OH)_8$ (black rust in the water)

4. Comparison of operating costs

The operational costs of the SRD compared with other methods of eliminating scale using a 100RT cooling tower for a cold chamber machine

	W/the SRD	W/Chemical feeding	W/O the SRD and chemicals
Cost of removal of scales and algae	W/algaecide feeder Approx. $180- $270/yr W/o algaecide feeder: $0/yr	Approx.$4,500–$6,300/yr	$0
Cleaning frequency of cooling tower	Once every 3-4 months	Once every 3-4 months	Once every 1-2 months
Electricity costs of a cold chamber machine (150KW) (Operating 24hrs X 365 days)	When no calcium carbonate Scales develop on the heat exchanger. Approx. $118,000.	When no calcium carbonate scales develop on the heat exchanger: Approx. $118,000.	When calcium carbonate scales develop on the heat exchanger. 0.3-0.4mm thickness; Approx.$118,000
Amount of CO2 emission reduction calculated from the above electricity consumption (Estimated 0 w/o chemicals)	Difference of electricity consumption X emission coefficient 252000KW X 0.555 = Approx.140, 000(kg)	Difference of electricity consumption X emission coefficient 252000KW X 0.555 = Approx.140, 000(kg)	$0
Amount of CO2 emission reduction in terms of eliminating scale method	A little emission reduction due to CO2 absorption in the process as mention on P1.	Increased CO2 emission due to emission in the process of chemical production	$0
Water Costs (Estimated water consumption for $3 / 1 ㎡)	$0 Loss only from evaporation, windage and draft w/ no drainage. (operating 24hrsX365days)	$6,500/yr 2,400M3/yr is estimated when 0.3% of water is used for drainage.	$6,500/yr 2,400M3/yr is estimated when 0.3% of water is used for drainage.
Drainage	Little water is discharged. Can be drained in the same way as rainwater.	Need to be drained into effluent treatment facility or sewer system because of the chemical.	Can be drained in the same way as rainwater.

Water Consumption calculations compared:

Sample: 100 RT(453KW) cooling tower

1) Evaporation loss (E)
E＝(tl-t2)/580 X L
t1＝inlet temp.(Centigrade)
t2＝outlet temp.(Centigrade)
Ｌ＝water circulation rte (Kg/hr)
t1-t2＝5 C
L= 100 X 3,900 / 5 = 78,000 (L/h) = 78,000 (Kg/h)
E= 5 / 580 X 78,000 = 672 (Kg/h)

2） Windage and draft loss (W)
W＝0.001XQ=0.001×78,000 = 78kg/h
3） Drainage (D)
D＝０
4) Make-up water （M）
M＝E+W+D＝672+78＝750(Kg/h)

With a regular drainage
Ex. In case for t1 – t2 = approx. 5 C）
D=LX0.003 ＝ 78,000×0.003
＝234 （Kg/hr）
a） 24hr X 365day operation
234×24×365＝2,049,840 （Kg）
b） 10hrs x 150 day operation
234×10×150＝351,000 （Kg）

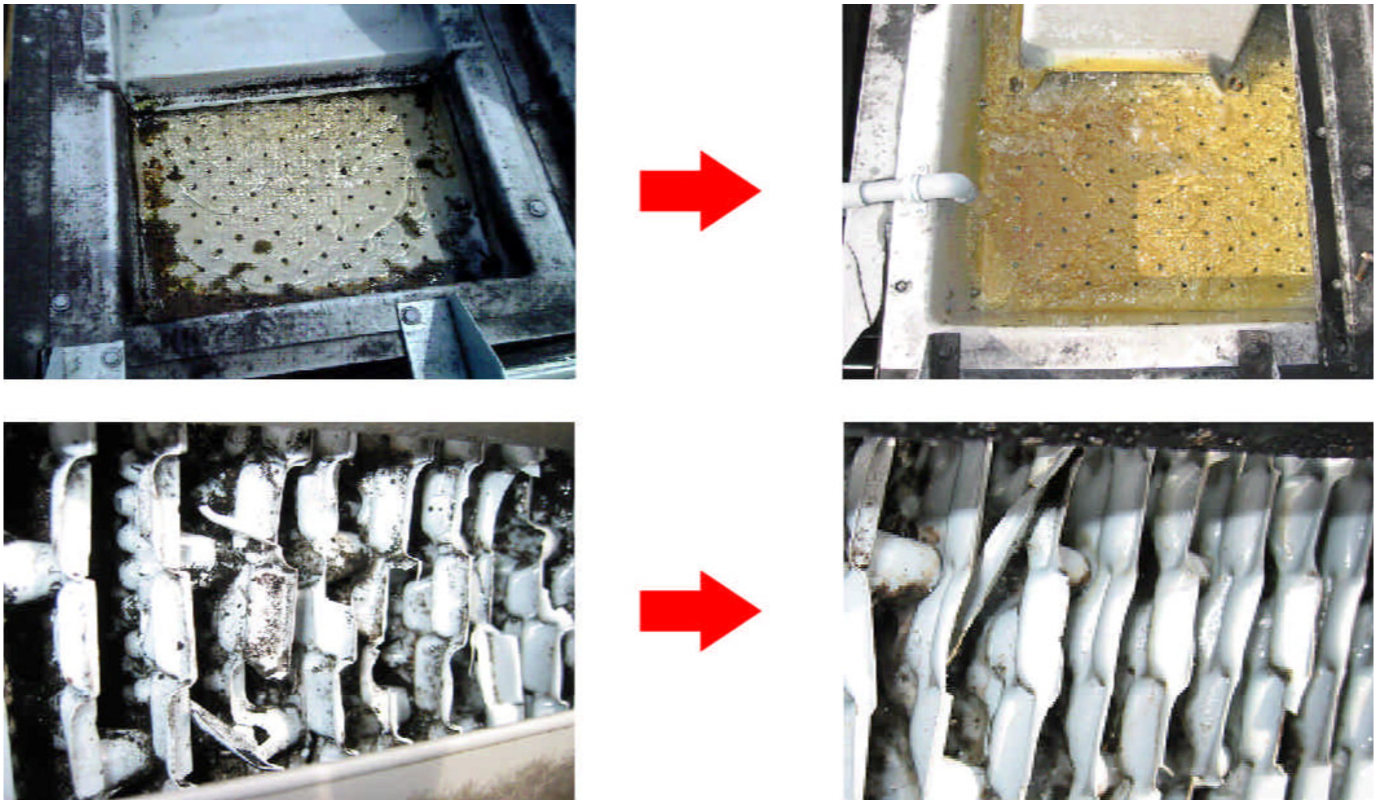
Water rate: $3 / m3
a) 2,049.84 X 3 = $61.4952
b) 351 X 3 = $1,053

Method of Calculating C02 emission. Calculated by multiplying the amount of electricity used in the period by an emission coefficient. The amount of CO2 emission per unit varies with the supplier. Therefore, electricity consumption is measured according to suppliers, so that the amount of emissions are calculated with respective coefficients and finally added up.

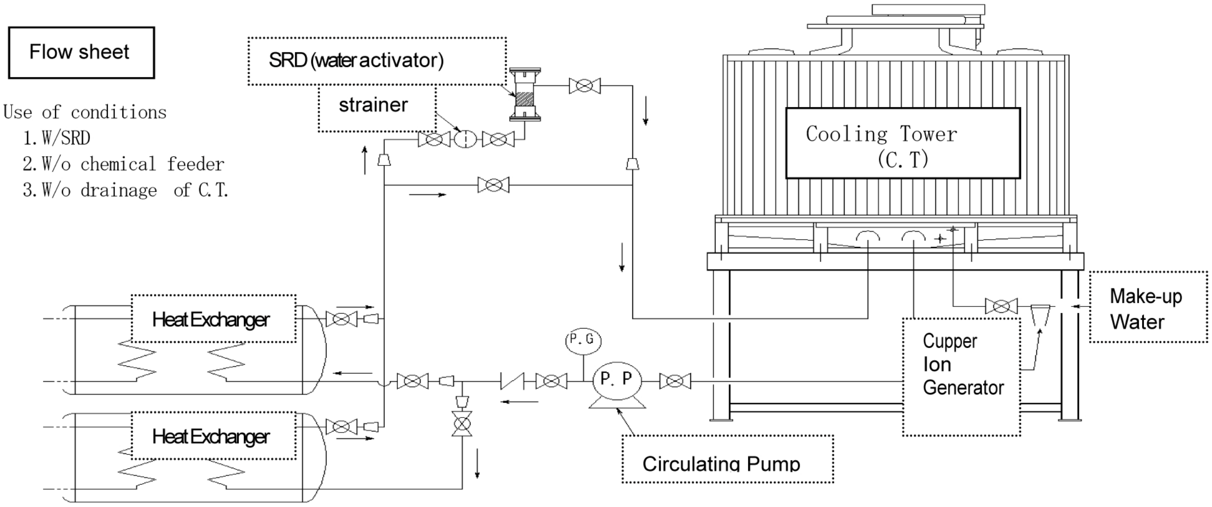
When a local public organization contracts with a single supplier, or when other suppliers' coefficients other than the main one are unknown, the above separate calculations are unnecessary.

Amount of emission (kg－CＯ２) =
Electricity consumption (kWh) X emission coefficient (kg-CO２/kWh)

The amounts are calculated according to suppliers and added up



Tested with a cold chamber machine at a plant in Kagoshima City, in corporation with Kagoshima Office of Mayekawa MFG. Co., Ltd.



Date	Action	Conductivity (μS/cm)	Condition
9/14/06	Installation of SRD	4,100	
10/24/06		4,740	●A minute salt-like scales were found on the end of the fill media of a Cooling Tower (C.T.).
11/22/06		1,990	●Scales on the end of the fill media slightly increased. ●A trace of sediment was found on the basin of a C.T. (The scales were soft and flaked off with a finger.) ●Scales were not found on the water pathway in the fill media.
12/25/06		1,970	●The amount of scales found on the end of the fill media was about the same as in November. No scales were found on the water pathway in the fill media. ●The sediment on the basin of a C.T. slightly increased.
1/20/07	Inspection of open end plate of H.E.	1,200	●The same amount of scales as in 06/9/24, when the tube sheet and the tube of a Heat Exchanger (H.E.)was checked after cleaning was found. ●Very little scales were found on the fill media of a C.T. ●The sediment of the basin of a C.T. had gradually increased.
6/29/07	Inspection of open end plate of H.E.	2,000	●No scales were found on a H.E ●Very little scales were found on the fill media of a C.T. ●About 60 litters of, or 3 buckets of sediment had settled down on the basin of a C.T.

5. **Test Results.** This test was conducted with the SRD installed in a cooling tower for a chiller unit at a company in Kagoshima, Japan. The test started on September 14, 2006 and continued until June 29, 2007 without chemical feeding or drainage of circulation water. While the conductivity rose to 5,000µs/cm in the beginning, it became stable around 2,000-3,000µs/cm afterwards.

Adhesion of scales was not apparent on the water pathway in the fill media throughout the test. Soft scales, however, had built-up on the end of the fill media where water did not go through, and where splashes had dried up. These soft scales piled up gradually, and flaked down onto the basin of the cooling tower. It is considered that the scale removal on the fill media of the cooling tower repeated as above.

The chiller unit tube bundle was cleaned before the test, and examined. Its scale adhesion examined.

On January 20, 2007, the end plate of the heat exchanger for the chiller unit was opened and checked for scale adhesion; little was seen in the tube. So, the end plate was closed without cleaning.

The end plate was opened again on June 29, 2007 and its condition was unchanged. Also, no scale adhesion was found on the brush that was put into a chiller unit as part of the test.

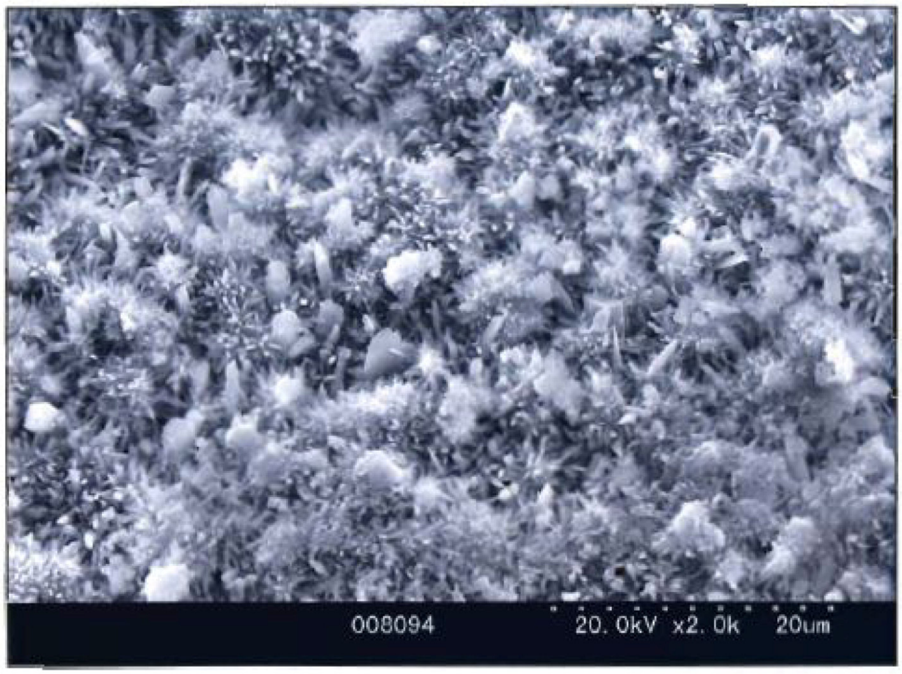
Thorough observation determined that the SRD inhibited scale adhesion more effectively than chemical feeding and increased the life span of the water cooling tower. There was a little adhesion of scales on the end of the fill media. Accumulation of Silica colloids on the basin of the cooling tower would require cleaning once every 3 or 4 months and a heat exchanger cleaning once every year.

MAYEKAWA MFG.Co.,Ltd

Installed SRD Unit

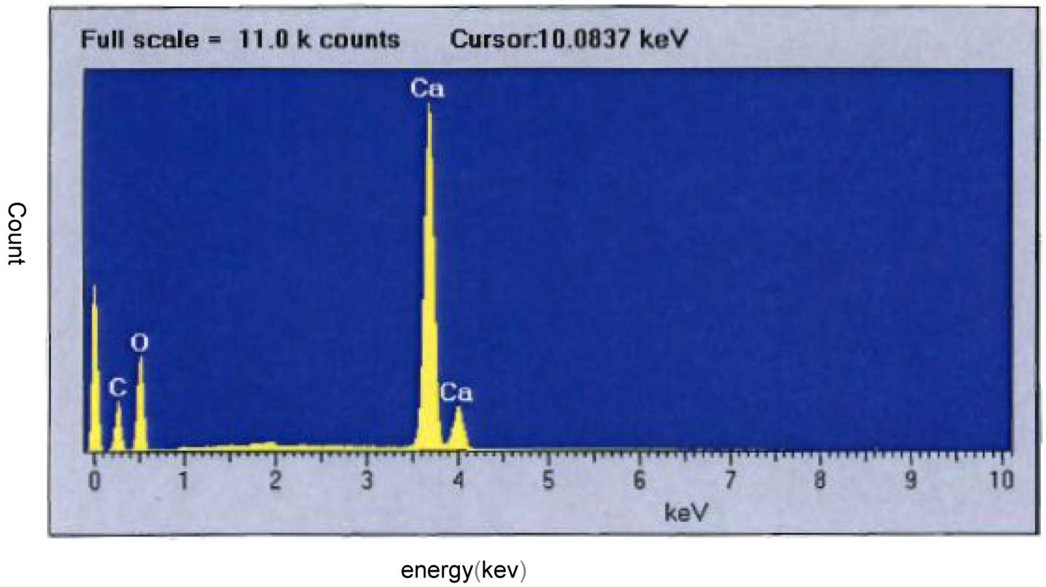
Electron micrograph of crystals formed in treated water

Sample: Cu heat exchanger tube (N0.2-1)



SEM photo

×2,000
5 μm



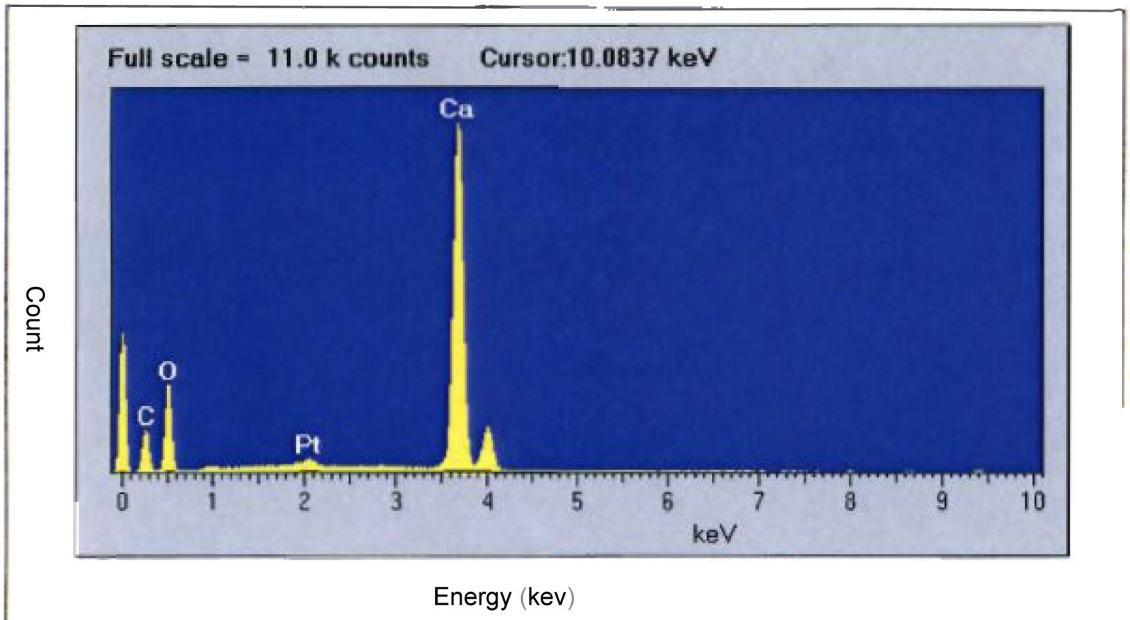
EDX qualitative analysis

Result of SEM-EDX elemental

analysis on the surface of Cu heat exchanger tube

Electron micrograph of crystals formed in untreated water

Sample: Cu heat exchanger tube (N0.4-1)



EDX qualitative analysis

Note) Detected Pt is an evaporated metal element.

Result of SEM-EDX elemental analysis on the surface of Cu heat exchanger tube

Questions and Answers:

Q: Why does the electrical conductivity of circulating water stay at a certain level and never exceed it?

A: Circulating water is cat-ionized, or positively charged, with an activator, and absorbs CO_2 in the air which has opposite charge. Absorbed CO_2 combines with ions such as Ca, Si, Mg in circulating water and forms crystals of $CaCO_3$, SiO_2, or $MgCO_3$. These crystals float in the water in colloidal states.

As a result of crystallization of Ca, Si and Mg ions, electrical conductivity of circulating water is reduced.

The circulating water, however, consistently evaporates in a cooling tower. The same amount of water is replenished, which increases the amount of ions. With the SRD, these ions are crystallized as described above so that electrical conductivity does not exceed a certain level.

Q: Why do crystallized $CaCO_3$, $MgCO_3$ or SiO_2 not attach to pipe walls or a heat exchanger?

A: As crystals are attached with positively charged water molecules, similarly-charged crystals never combine to each other to form scales, nor adhere to pipe walls or to a heat exchanger which has similar electrical charge.

Q: Why isn't drainage of circulating water required?

A: With a chemical feed method, chemicals only inhibit the formation of scales in high electrical conductivity. They cannot act on the conductivity itself. Therefore, drainage is required to reduce conductivity before saturation. On the contrary, this scale removal unit does not require drainage because this unit can control a rise in electrical conductivity and inhibit crystallization.

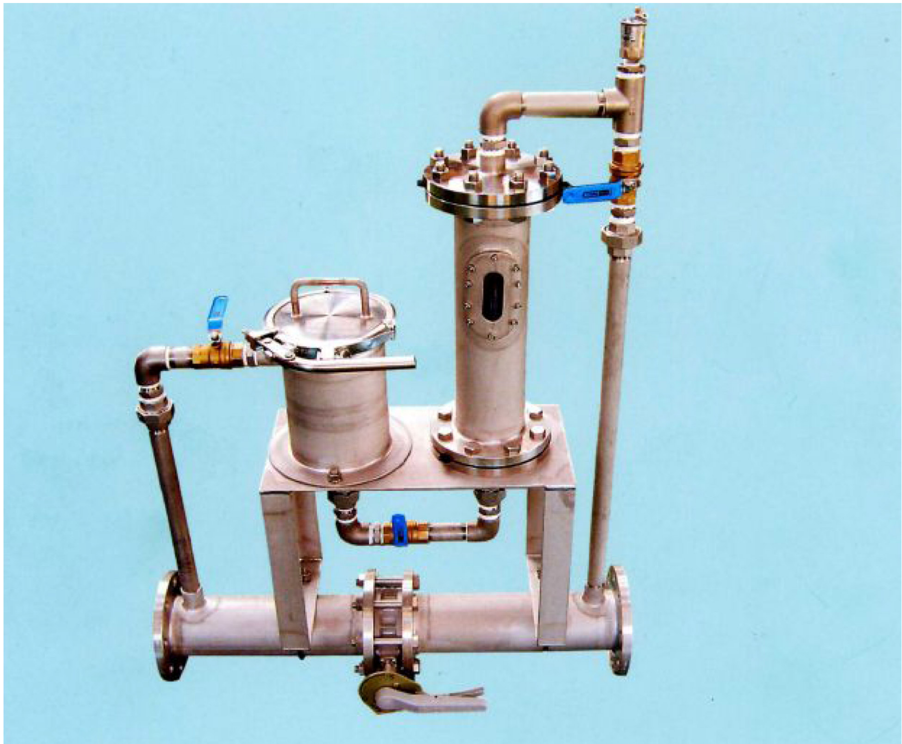
Q: Why does a cooling tower need cleaning every three or four months?

A: Since crystals are deposited and accumulated on the bottom pan where the circulating water flow is slow, a cooling tower only requires a simple cleaning. All you have to do is open the blow valve and wash away the deposit with a scrub blush.

Which SRD size suitable for your Water Cooling Tower?

DATE: ______________________

Water Cooling Tower	**Data**
Cooling capacity (R.T)(KW)(Kcal)	
Type of cooling tower (open or closed)	
Volume of circulating water (L/min)	
Volume of Make-up water (L/min)	
Diameter of circulating water pipe (outlet)	
Operating time	
Type of equipment (cold chamber machine, power generator, etc.)	
Temperature at a cooling tower hatch (values in the design)	
Chemical feeding requirement	
Cost for chemical feeding ($/year)	
Drainage requirement	
Source of replenishing water (tap water, well water)	
Cost of tap water ($/M3)	



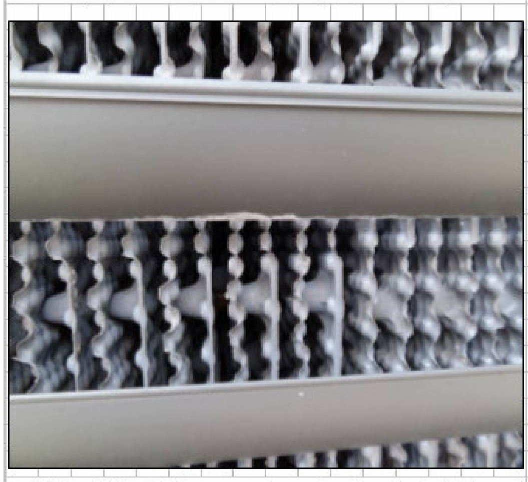
Hitachi


CT−4
コンプレッサー冷却

Kita Kyushu Factory of OCC (Ocean Cable & Communications)
(A closed-styled cooling tower for the air compressor)


(1) S．R．D本体写真 (SRD Photo)


(2) (SRD with the cooling tower)


Filling Material two months after the installation of


Copper tube inside a cooling tower two months after


(5) Copper tube inside the cooling tower without SRD.

A lot of scale is attached to the tube irrespective of chemical injection.

NB: The cooling tower with SRD has circulated the water without any chemical injection.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LIST OF JAPANESE SRD CUSTOMERS

Sumitomo Rubbers Corp.

Nippon Steel

UBE Industries Corp.

Sasebo Heavy Industries Corp.

Mitsubishi Heavy Industries Corp.

Bridgestone Corp.

Baxter Corp.

LifeWater Sciences International

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