Reduce Reuse Recycle Plan Do Check Act Hazard Identification & Risk Assessment Communicate Observe Discover Develop Innovate Acquire Share

Share

SORA GREEN Technologies

Alternative Cooling Tower Water Treatment System in Non Traditional Way

Content

- **SORA GREEN Technologies**
  - Introduction
  - Sora system features
  - Sora system products & exhibits
  - Sora system benefits
  - Sora system comparison with traditional system
  - Singapore and International acknowledgement

Introduction

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- **SORA** Non-traditional Cooling Tower Water Treatment System
  - It is a revolutionary technology promoting “from Chemical to Natural”
  - Able to address cooling tower water major pollutants issues
  - Able to conserve water usage and maintain system energy efficiency
    - Improve water solubility and allowing water to hold in suspension more of dissolved solids.
      - Reduce blowdown and thus conserve water usage. Result may vary from site to site
    - Create smaller water cluster size, improve permeability and enhance cleansing effect – De-scale & avoid energy wastage. Maintain energy efficiency in heat transfer
    - Prevent biofilm formation which reduce heat transfer - improve energy efficiency
      - Biofilm is 4 to 5 times worst in heat conductivity than hard scale
  - Promotes low Cost of Ownership and brings financial benefit to our customers
    - Eradicate chemical & associated EHS cost, cumbersome administrative work, conserve water and avoid energy wastage
  - It is an effort to support Green Building and Protect Mother Earth

ECO Friendly, Safe, Non-Polluting & Effective

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- **SORA cooling tower NT water treatment system utilizes the synergistic effect of "metal ions + SORA natural ceramics + Repulsive Magnets " to terminate bacteria and inhibit algae growth, clean circulating water and return the subject water to a condition closer to clean natural state without affecting humans and not contaminating the environment**
- **Well accepted and widely used in hospitals, healthcare facilities, nursing homes, hotels and large commercial complex**
  - These places are vulnerable of having "high risk occupants" with compromised immune system and they are extremely susceptible to Legionella bacteria, cause of Legionnaires' disease.

Metal Ions + SORA Natural Ceramic + Repulsive Magnets

Cooling Tower Water Pollutants

Microorganism like bacteria(Legionella), algae in water

Corrosion & rust at pipes

Biological fouling is the root of most cooling-loop water treatment problems, according to many experts.

Scaling at heat exchanger
Fouling at tower's infill

Foam, dirt, sludge at cooling tower basin due to interaction of chemical cocktails

SORA System
Features

Pending Patent Application in Singapore

Metal Ion Generating Device and Cooling Tower Sterilizing and Purifying System

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1. Control of Microorganism

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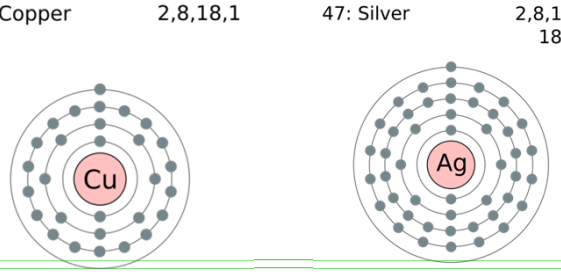
Metal Ions + SORA Natural Ceramic + Repulsive M

- **Metal Ions – Silver & Copper Ions as disinfectants, Ag^{+} Cu^{2+}**
  - Copper-silver ionization by Electrolysis process.
  - **NASA** use silver ionization for drinking water production aboard Apollo space ship since 1960 and Space Shuttle program
  - In Japan, UK, US & Australia copper-silver ionization is applied in many hospitals successfully for the deactivation of **Legionella** pneumophilia disease
  - Industrial-size copper-silver ionization is approved by the U.S. Environmental Protection Agency for *Legionella* control and prevention

http://bionicpools.com/HistoryLessons.html



Copper & Silver Ionization – Biocidal Process

Metal Ions + SORA Natural Ceramic + Repulsive M

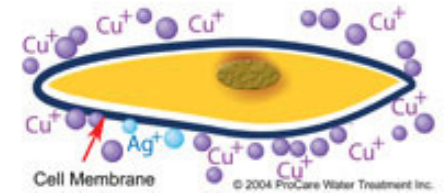
SORA Silver & Copper generators release precise and safe concentrations of copper and silver ions into the circulating water system

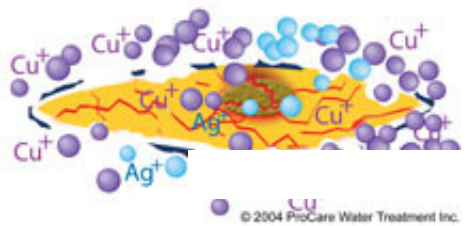
+ve charged Cu and Ag ions travel within the water system and penetrate biofilm*. These ions will bind themselves to negatively charged sites like bacteria cell walls. Eg: like *Legionella*.

Upon binding with these microorganisms, Cu & Ag ions attack in a multiphase process to disrupt the overall cell metabolism causing cellularlysis (death).

Safe ion concentration levels are maintained and able to provide long-term residual protection**

The copper and silver ions attach, through electrostatic bonds, to negatively charged sites on bacterial cell walls.
This distorts and weakens the cell wall allowing penetration of the silver ions.
The silver ions attack the cell by binding at specific sites to DNA, RNA, cellular protein and respiratory enzymes denying all life support systems to the cell, causing death.





* Bio-film produced by bacteria impedes 4-5 times more heat transfer resistance than calcium carbonate hard scales. Both scaling and biofilm impede heat transfer

** Unlike chemical effectiveness which is short span and need regular top up.

Copper & Silver Ionization – Biocidal & Algicidal Effects

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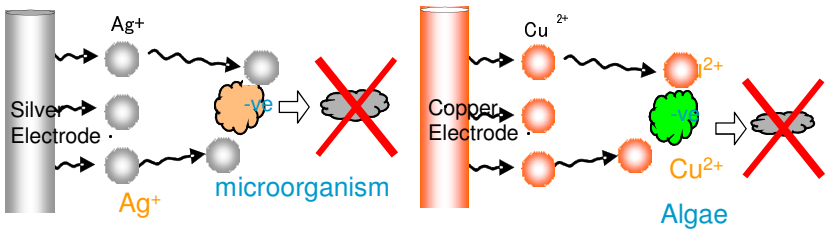
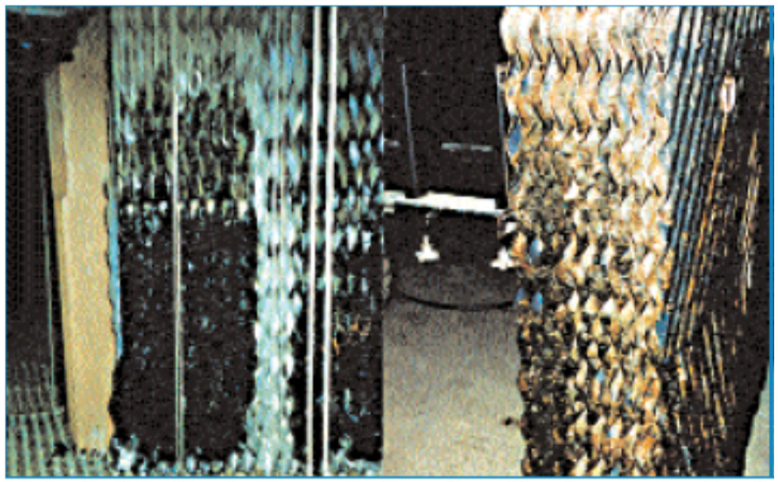
Metal Ions + SORA Natural Ceramic + Repulsive M

•Metal Ions – Ag+ Cu2+ Ions as Disinfectants

- These ions are non-volatile, long-lasting and maintain its biocidal effect for a long time unlike chlorine, UV and ozone where effectiveness is only short span and localized.
- Cu^{2+} ions attach to algae, inhibit the growth and finally caused the death of algae. Legionella propagate symbiotically with algae and amoeba. By stopping algae growth will lead to enhancement of biocidal effect for Legionella indirectly.





Biological fouling is the root of most cooling-loop water treatment problems, according to many experts.

Cooling Tower Infill Fouling

Reduce Reuse Recycle Plan Do Check Act Hazard Identification & Risk Assessment Communicate Observe Discover Develop Innovate Acquire Share

2. Control of Scaling & De-Scaling

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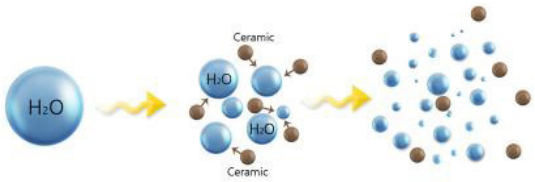
Metal Ions + SORA Natural Ceramic + Repulsive M

•SORA Natural Ceramic + Repulsive Magnets

– Sora natural ceramic generate infrared rays which act on water molecules and break up molecules bonds. Consequently, water cluster become smaller and surface active functionality such as permeation and cleansing is enhanced. Scales will break up gradually and separates from cooling tower walls, infills, and pipe walls.



– Scale separation with Sora system occurs in a large surface area & gradually. It is not concentrated at any spot or penetrates deep enough to reach the metal surface. Leaving a layer of protective coating on the metal surface to act as barrier separating the water to contact directly with metal

– Repulsive magnets induces higher dispersion on metal ions and minimize crystal accumulation on the electrodes. This will ensure good performance of electrodes and emission of metal ions.

3. Deterring Corrosion

SGTPL

Metal Ions + SORA Natural Ceramic + Repulsive M

- **SORA Natural Ceramic + Metal Ions**
  - Corrosion would not take place unless oxidation occurs in water
  - Sora natural ceramic generates deoxidizing water and thus reduce the rate of rust formation and provide deterrent to corrosion. Existing corrosion, will slow down its progress.
  - Sora system also prevent bio-corrosion like pitting caused by anaerobic bacteria flourish underneath Biofilm since Biofilm is eradicated *
  - Sora system create triiron tetraoxide (Fe_3O_4 – black rust) which is known to protect surface from oxidation and consequent corrosion to Fe_2O_3 – red rust
    - Specific causes should be determined if corrosion is an issue and a suitable remedy can be applied

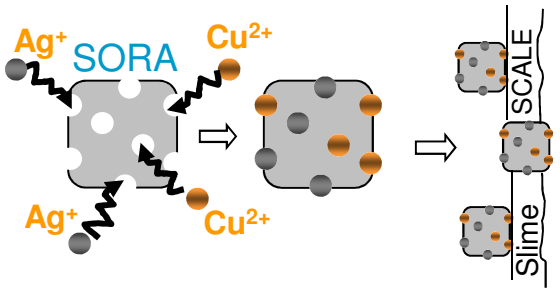
* Biofilm will lead to Biofouling and one of the critical problem of biofouling is under deposit corrosion. Certain organism, Eg: sulfate-reducing bacteria, generate corrosive hydrogen sulfide, which cause severe pitting on metal surface and that will lead to leaks

Sora system bring out the best biocidal, algicidal & cleansing effect

SGTPL

Metal Ions + SORA Natural Ceramic + Repulsive M

- **SORA Natural Ceramic + Metal Ions**
  - Sora natural ceramic' surface layers continuously liquate out and revealing a new layer
  - It has an adsorption characteristic that will absorb Cations like Ag+ Cu2+ and these ions are stored in the nano pores of SORA particles
  - These liquated surface that contains Silver and Copper ions spread extensively to all corners of the cooling water circuit with enhanced biocidal and algicidal effect
  - The excellent absorptive power of SORA will also absorb and remove unwanted metal ions and Trihalomethane in water. It cleanses the water from impurities
  - The combine effect of Ag^{+} Cu^{2+} display its strong biocidal and algicidal effect and also effectively deal with biofilm & biofouling issue.



Trihalomethane is a cancer inducing substance

SORA Cooling Tower

Non-Traditional Water Treatment System Products and Exhibits

Sora Green Technologies Pte Ltd

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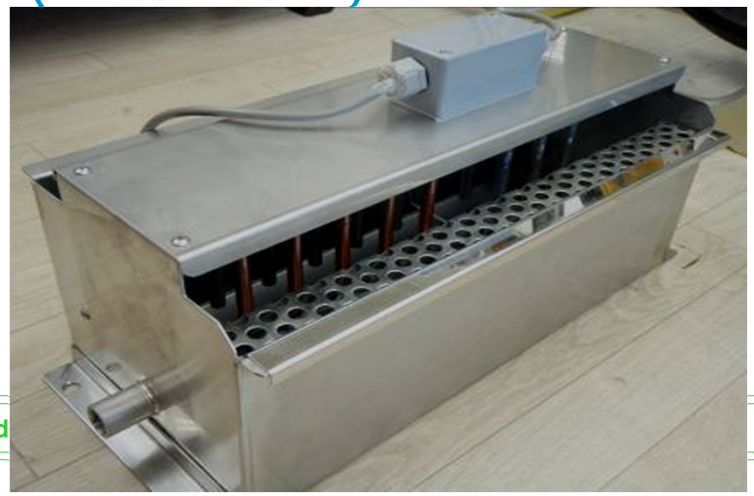
Cooling Towers

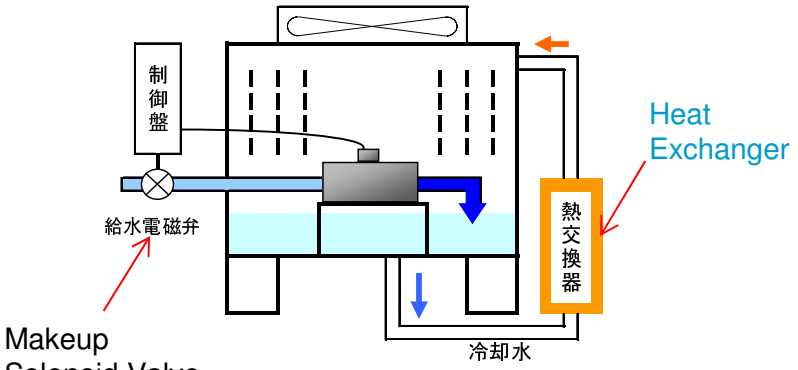
Content

1. Out of water Model
2. Submerged Model
3. Detached Model
4. Results after installation of Sora System

Out of Water model

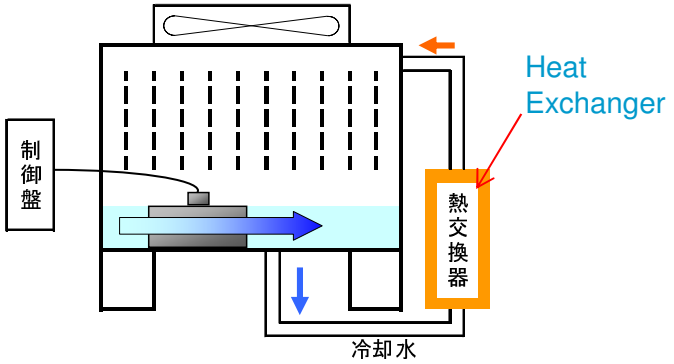
(CTSU-250ST)





Out of Water Model Schematic

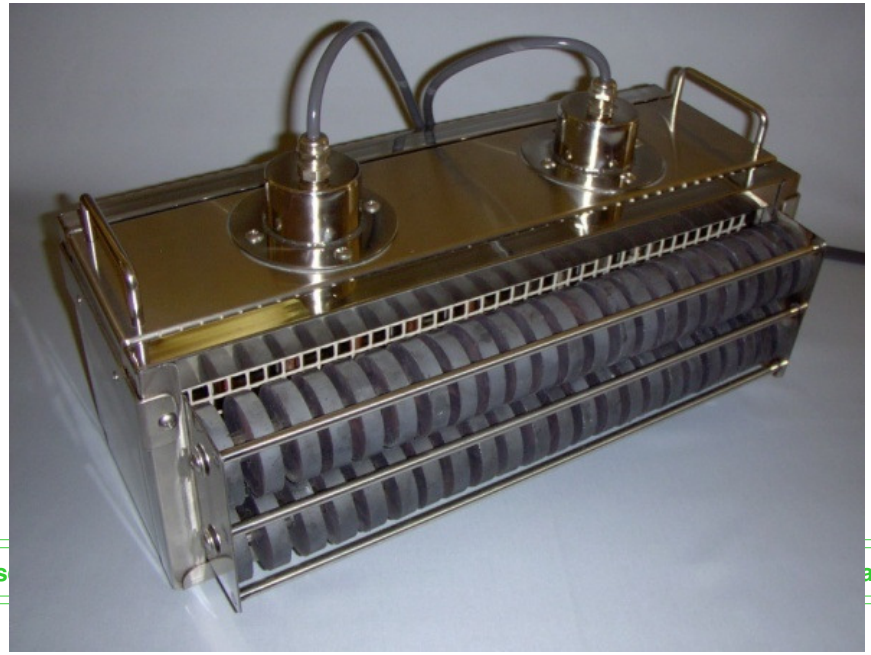
Control Panel

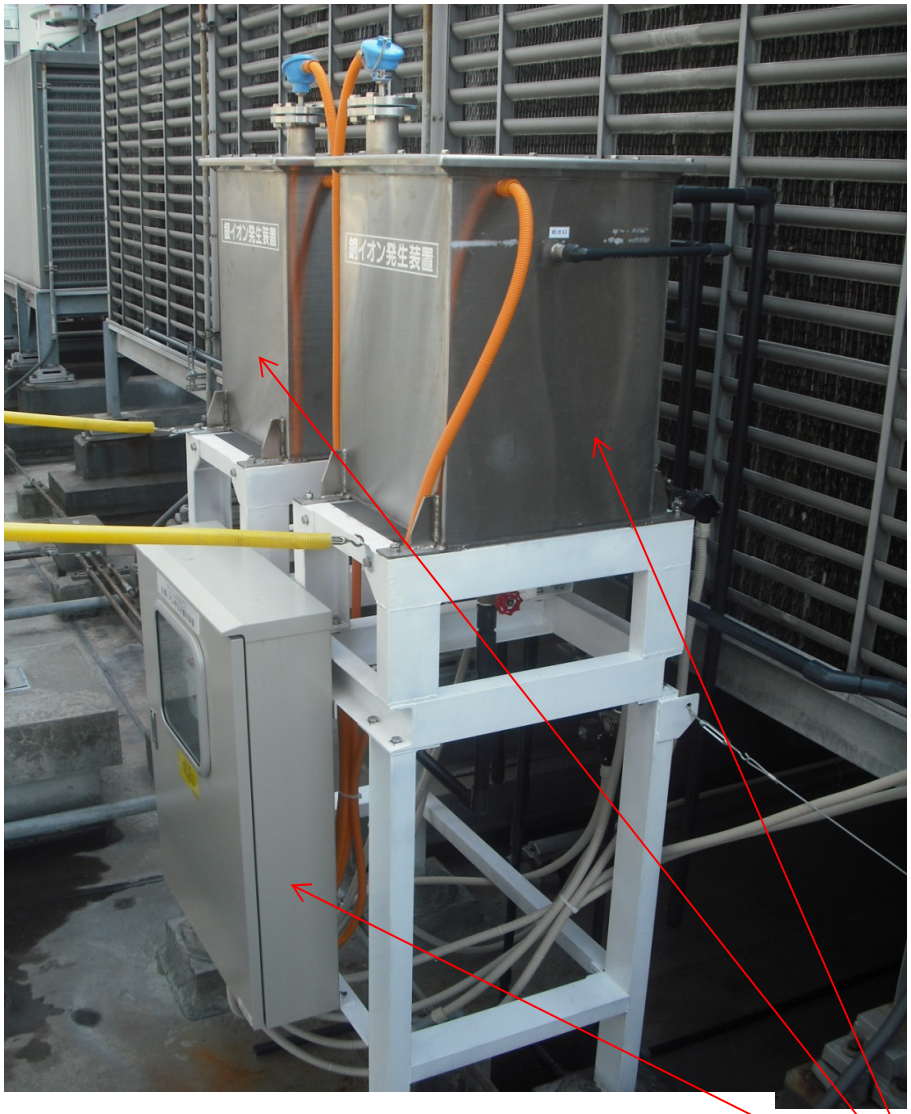


Submerged Model Schematic

Submerged Model

（CTSL-250M）





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Osaka Police Headquarter
Hospital Cooling Towers

Detached Model

serving multiple cooling tower cells

It consists of one silver and one copper ion generator tank and control panel

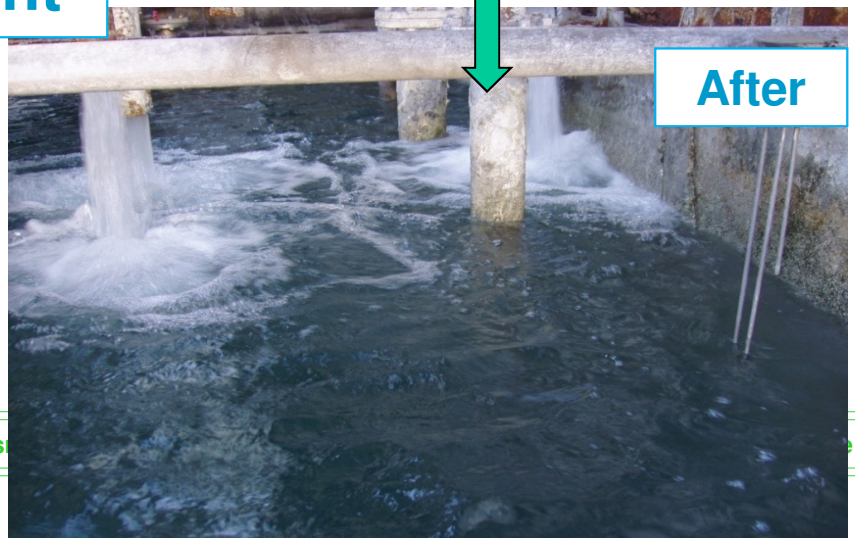
Cooling tower infill fouling & algae growth

(after 1 month)

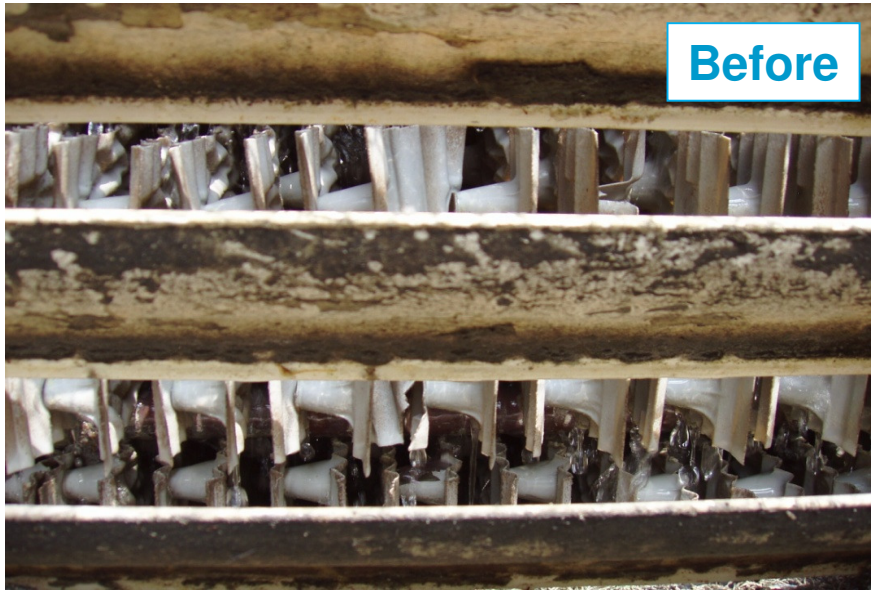
After Installation of Sora system & Treatment

Cooling tower basin slime & algae growth

(after 1 month)

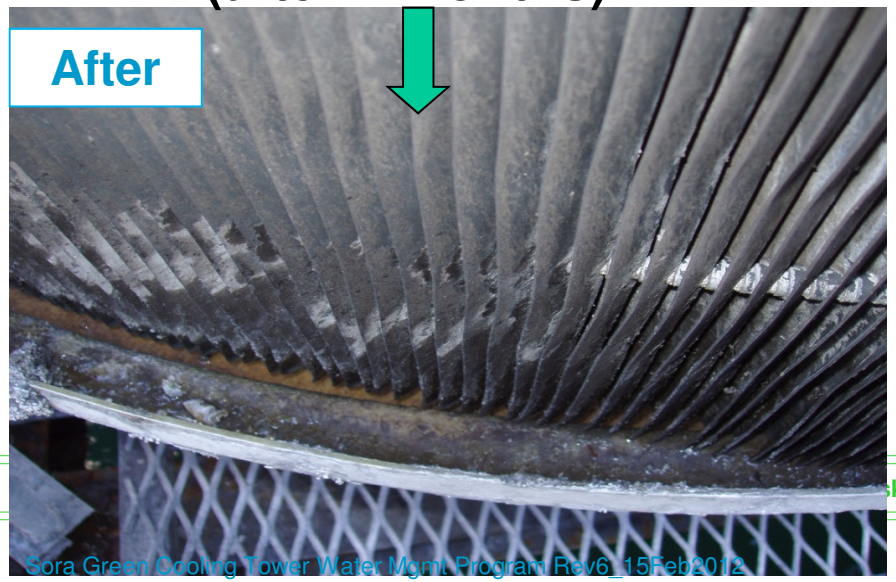


Slime at bottom of cooling tower

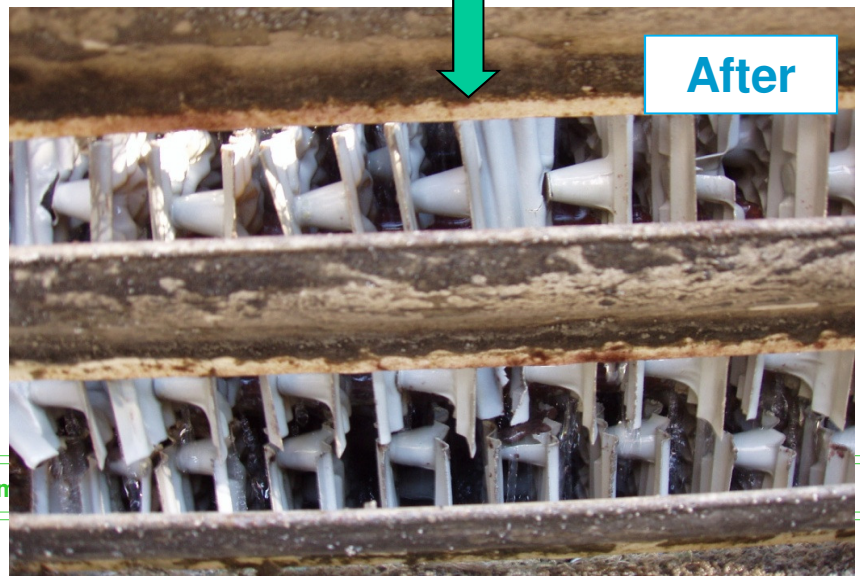


Cooling Tower infill slime and fouling

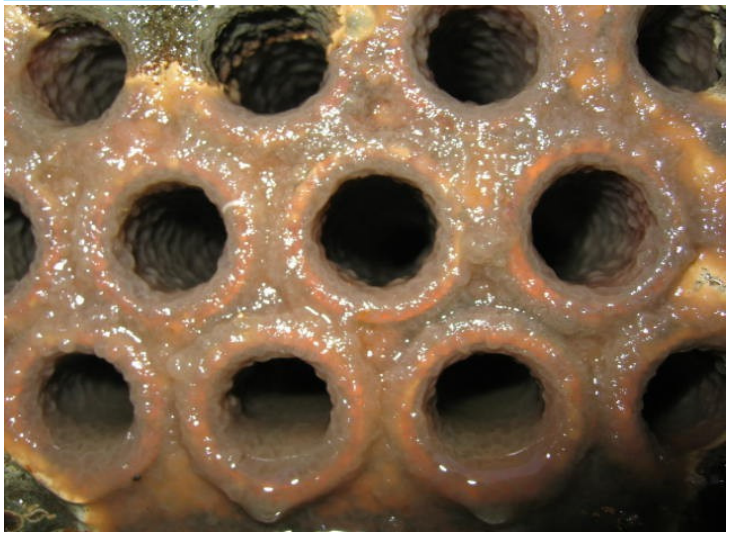
(after 2 months)



(after 3 months)

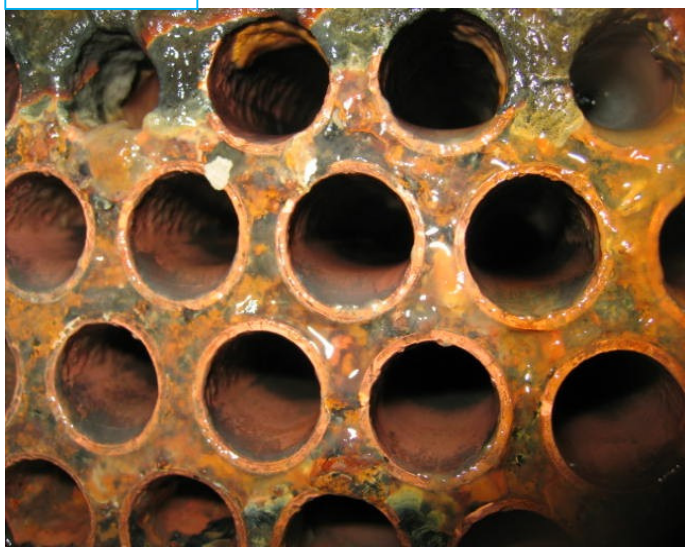


Before



Slime and biofouling at heat exchanger

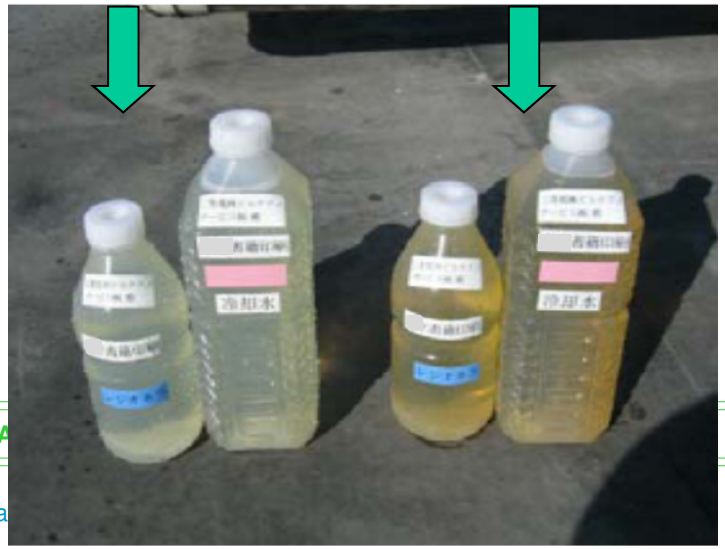
After



Slime and biofouling is prevented

Comparison of Turbidity of CT water

With SORA treatment **Without SORA treatment**



Results Demonstration

Water Quality of 400RT Cooling Tower (New Installation)					
Chemical Treatment & Sora Non-Chemical Water Index Comparison in Japan site					
Performance Index	Units	Datum	Before Treatment	Chemical Treatment after 4 months	Sora System Treatment after 4 months
pH@25 degC		6.5 ~ 8.0	8.5	8.6	8.4
M Alkalinity	mg/l	100	120	140	110
Total Hardness	mg/l	200	360	150	60
Conductivity	µS/cm @25°C	800	1100	600	400
Ammonia Ion	mg/l	1.1	0	0	0
Chlorine Ion	mg/l	200	120	180	30
Sulfuric Acid Ion	mg/l	200	180	220	80
Silica	mg/l	50	86	170	45
All Ions	mg/l	1	0	0	0

"P" alkalinity measure carbonate ion (CO_3^{2-}) – permanent alkalinity and not change by boiling
"M" alkalinity measure both carbonate (CO_3^{2-}) and bi-carbonate (HCO_3^{2-}) . It is called Total Alkalinity and will change after boiling (HCO_3^{2-} becomes CO_3^{2-})
Total Hardness refer to all dissolved mineral

Results Demonstration

Test Result of Bacteria Killing Effect by SORA System (for reference purpose only.
Other factors like weather, field installation conditions may affect the test result)

Specimen	Analyte	Initial Bacteria Counts	After 3 hours	After 6 hours	After 48 hours	After 72 hours	After 12 days
Legionella	SORA Water Sample	1,100,000	<100	<100	<100	<100	<100
Salmonella	SORA Water Sample	50,000	<10	<10	<10	<10	<10
Pseudomonas Aeruginosa	SORA Water Sample	60,000	<10	<10	<10	<10	<10
Bacillus Coli	SORA Water Sample	45,000	<10	<10	<10	<10	<10
Stphylococcus Aureus	SORA Water Sample	30,000	<10	<10	<10	<10	<10

Test carried out by Japan Food Research Laboratory

<10, <100 means that it is below the detection limit

SORA System
Benefits

Pending Patent Application in Singapore

Metal Ion Generating Device and Cooling Tower Sterilizing and Purifying System

Reduce Reuse Recycle Plan Do Check Act Hazard Identification & Risk Assessment Communicate Observe Discover Develop Innovate Acquire Share

Result Demonstration

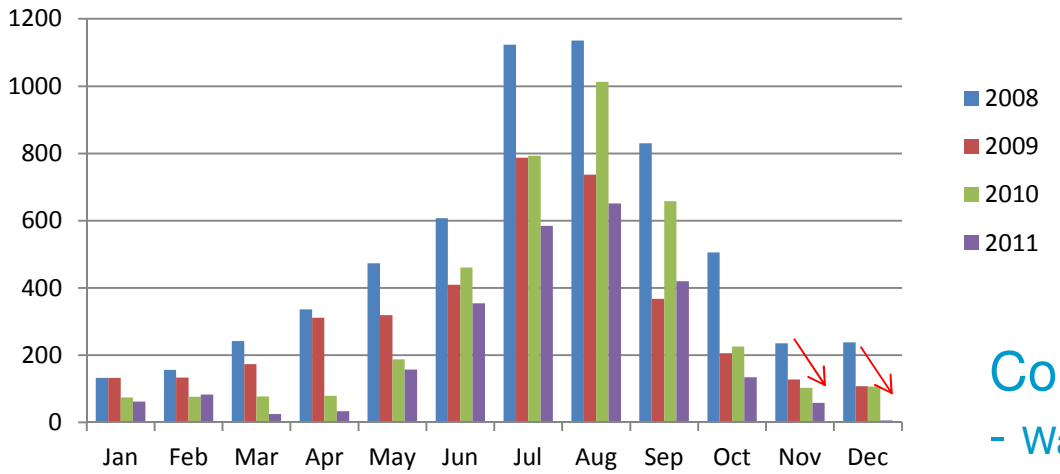
Conserve water usage

Site A water consumption (m^3) before and after installation of Sora non-chemical system (for reference only, result may vary from site to site)

Specific detail is not disclose because of request from Customer

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Cummulative
2008	132.4	156.4	241.9	336.3	473.1	607.9	1122.9	1135.3	830.5	505.7	235.3	237.8	6015.5
2009	132.2	133.8	173.9	311.4	319	409.3	787	736.7	367.4	205.4	127.6	108.1	3811.8
2010	74.7	76.7	77.1	79.1	187.5	461	793.3	1013	658	226	103.4	106.5	3856.3
2011	62.3	82.7	24.5	33.9	157	354	584.8	651.2	420	134	58.6	6.3	2569.3

Cooling Tower Water Consumption m^3 before and after installation of SORA system.
Sora system operate since Jan'2009



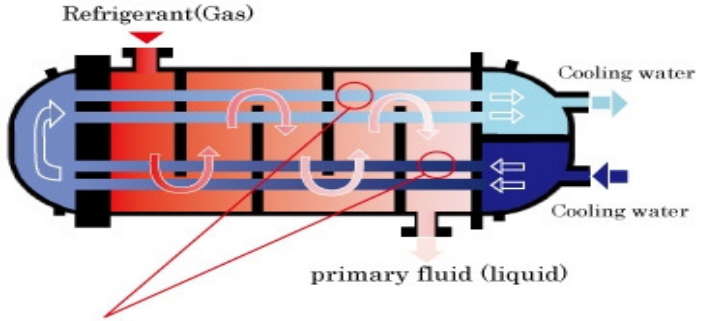
Conserve water usage

- Water consumption reduced every year

Scale vs Consumption of Electricity

- Sora System maintain optimum heat conductivity and maintain heat exchanger efficiency
- Avoid energy wastage

- **Typical shell & tube heat exchanger**



Pipes Image

l_1 / λ_1 : Thermal Resistance by oil film

l_2 / λ_2 : Thermal Resistance of Tube (Copper)

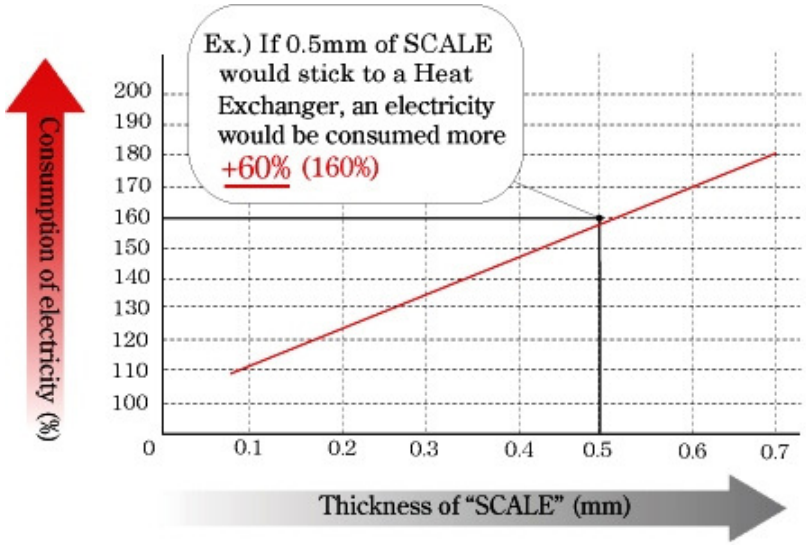
l_3 / λ_3 : Thermal Resistance by Scaling

R: Thermal Resistance by oil film

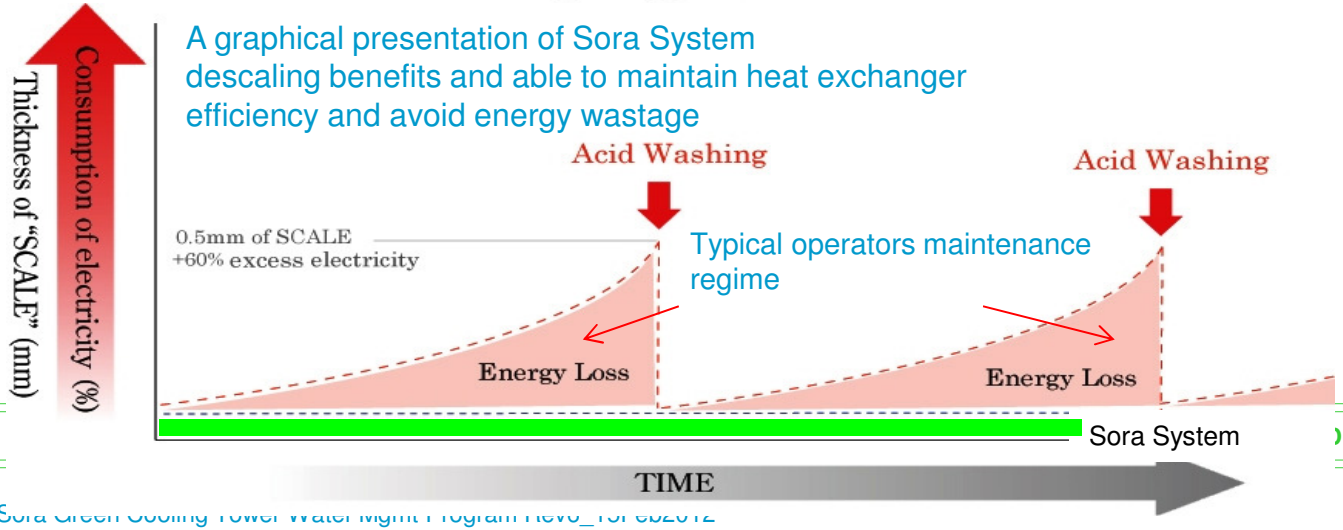
α_R : Thermal conductivity (Refrigerant) [KW/(m²· K)]

α_w : Thermal conductivity (Cooling water) [KW/(m²· K)]

$$R = \frac{1}{\alpha_R} + \frac{l_1}{\lambda_1} + \frac{l_2}{\lambda_2} + \frac{l_3}{\lambda_3} + \frac{1}{\alpha_w}$$



A graphical presentation of Sora System descaling benefits and able to maintain heat exchanger efficiency and avoid energy wastage



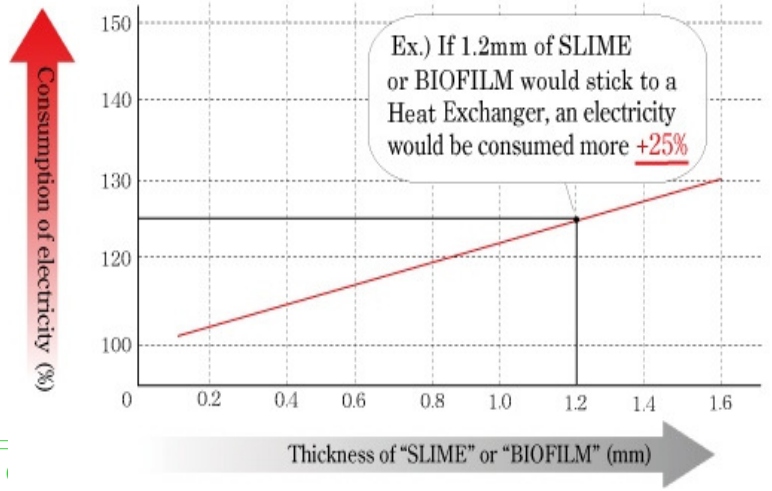
Microorganism – Biofilm & Heat Conductivity

- **Heat Transfer permeability of scale and biofilm**

Thermal conductivity comparison of deposit forming compounds and biofilm

Substance	Thermal Conductivity ($Wm^{-1}K^{-1}$)
$CaCO_3$	2.6
Fe_2O_3	2.9
Biofilm	0.6

Biofilm
Poor conductivity → Higher Fouling Factor → More energy needed to generate same amount of cooling → Poor Coefficient of Performance



Fouling – Affect Energy Efficiency

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Effect of Fouling factors on Evaporator and Condenser of Chillers - Data extracted from McQuay's Chillers – ARI Guideline E-1988

Table 1 - Evaporator fouling factors

Fouling factors m²° K/kW	Cooling cap. Correction factor	COP Correction factor
0,044	1	1
0,088	0,986	0,994
0,132	0,972	0,987

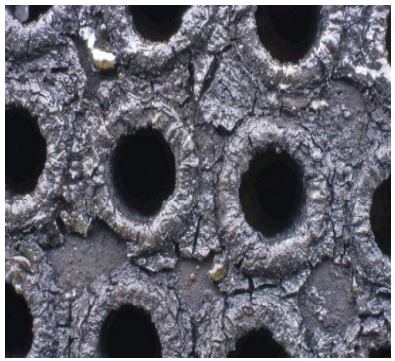
This value had reduced to 0.018 in 1997

Table 2 - Condenser fouling factors

Fouling factors m²° K/kW	Cooling cap. Correction factor	COP Correction factor
0,044	1	1
0,088	0,99	0,973
0,132	0,981	0,945

HOW FOULING FACTORS AFFECT CHILLER PERFORMANCE

Increase in Fouling Factor ft²° F/(Btu/hr)	% of Efficiency	Additional Power Req
.0005	100%	0%
.0015	94%	11%
.0025	80%	22%
.0036	58%	33%
.0045	36%	44%



Tubes Fouling

Cooling Tower Infill Fouling

SORA System
Comparison with Traditional System

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Share

Comparison between Sora System with Traditional Chemical Treatment System

Description	Sora System	Chemical Treatment
Bacteria & Algae Control	- Copper & Silver Ionization has excellent biocidal and algicidal effect and its sterilizing effect is long lasting - Synergistic effect of Sora Natural Ceramic absorptive characteristic provide maximum sterilization to the entire water circuit - Able to penetrate deep into biofilm	- Chemical biocide function deteriorate rapidly and get thin down with replenished water. They require frequent replenishment . Increase CoO - Incapable to penetrate deep into Biofilm - Chlorine based biocide can cause corrosion
Scaling Control	- Water cluster become smaller . - Permeation and cleansing effect is enhanced and accelerated. Scale gradually peel off - Repulsive Magnet acts on metal ions and induces higher dispersion to minimize crystal accumulation on electrodes. Ensure good performance of electrodes	- Phosphate based scaling inhibitor is environmentally unfriendly when discharge into public water collection system. - Chemical used for descaling can be acidic and need special treatment prior to discharge to public collection system - Chemical used for descaling can cause corrosion and shorten equipment life span

Comparison between Sora System with Traditional Chemical Treatment System

SGTPL

Description	Sora System	Chemical Treatment
Corrosion Control	- Corrosion will not take place until oxidation occur in water. - Sora catalyst generates deoxidizing water and thus reduce rate of rust formation - Formation of Fe3O4(very stable and protect metal) in contrast to Fe2O3 which promotes rust formation	- Phosphate and Nitrate corrosion inhibitor cause pollution and also they are nutrient for microorganism and promote growth of algae and bacteria - Biocide which are Chlorine based cause corrosion when over fed
Impact to Environment	- Protect the environment as it is a non-polluting water treatment system	- Damaging to the environment and ecological system
Water Saving	- Reduce water usage since able to operate at higher cycle of concentration (CC) - Singapore BCA Green Mark. Part 2 – Water Efficiency. NRB 2-4(a) Water Consumption of Cooling Towers 1 point for CC of 7 or better Link to customer water saving	- Chemical increase TDS and result in higher blowdown or bleed off water wastage Link to BCA Green Mark Page 148

Comparison between Sora System with Traditional Chemical Treatment System

SGTPL

Description	Sora System	Chemical Treatment
Treatment effectiveness	- Not human dependent and automatically control - Long lasting with effective concentration	- Human dependent & difficult to control as there are many variables to balance like pH and complex chemical interaction - Effectiveness is short span
Safety, Prestige and cost of ownership	- Low Safety Risk - It is a modern innovation specially design to meet demanding customer and regulation	- High risk of chemical exposure - Old fashion treatment method - Higher cost of operating chemical system because special PPE are required, special storage space with secondary containment and emergency ventilation. - Special treatment prior to discharge to public sewage maybe required - Not inline with the good spirit to protect our earth and next generation

SORA System

Singapore & International

Acknowledgement

Pending Patent Application in Singapore

Metal Ion Generating Device and Cooling Tower Sterilizing and Purifying System

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Singapore Green Building Design Guide
- Air Conditioning Buildings

SGTPL

6. INNOVATIONS

6.6. NON-CHEMICAL WATER TREATMENT

Use non-chemical water treatment system to control bacteria, scale, corrosion, algae and slime. Non-chemical water treatment system could consist of the following components:

- an electromagnetic descaler for scale control
- an electromagnetic magnetite generator for corrosion control
- a copper-silver ionization unit for bacteria, algae and slime control

Sora system is capable of delivering all these three functions without the need of separate individual system

BENEFITS

- Saving in energy consumption due to reduction in scale, corrosion and biofilm
- Environmental friendly as the system uses no chemical
- Able to control microbiological growth and minimize Legionellosis disease outbreak
- Improve cooling tower's cycle of concentration
- Discharged blow-down water from cooling tower can be recycled and reused for other needs such as watering plants

hare

National and International Acknowledgement

The following are some of the National and International associations that acknowledge the copper silver ionization process in relation to particular applications.

Associations	Acknowledgment Quotes	Sources
Environmental Protection Agency	The Environmental Protection Agency recognizes copper silver ionization as a "control method designed to disinfect an entire water distribution system" for Legionella control and prevention.	Sept. 2000 - LEGIONELLA : DRINKING WATER FACT SHEET Nov. 1999 - LEGIONELLA : Human Health Criteria Document
Occupational Safety & Health Administration	Occupational Safety & Health Administration states that a mean to control Legionella growth includes “the use of metal ions such as copper or silver (which have a biocidal effect)”.	OSHA technical manual on Legionnaires' disease, section iii: chapter 7

Note: All of the "Acknowledgment Quotes" mentioned on this page clearly identify the document sources and can be verified by visiting or each of the associations website. All Acknowledgments are in relation to the copper silver ionization process and have no relation to a specific brand or type of ionization technology. It should however be noted that there are major engineering differences between types of ion generators currently available around the world.

THANKYOU

Reduce Reuse Recycle Plan Do Check Act Hazard Identification & Risk Assessment Communicate Observe Discover Develop Innovate Acquire Share

SGTPL

Reduce Reuse Recycle Plan Do Check Act Hazard Identification & Risk Assessment Communicate Observe Discover Develop Innovate Acquire Share

Sora System

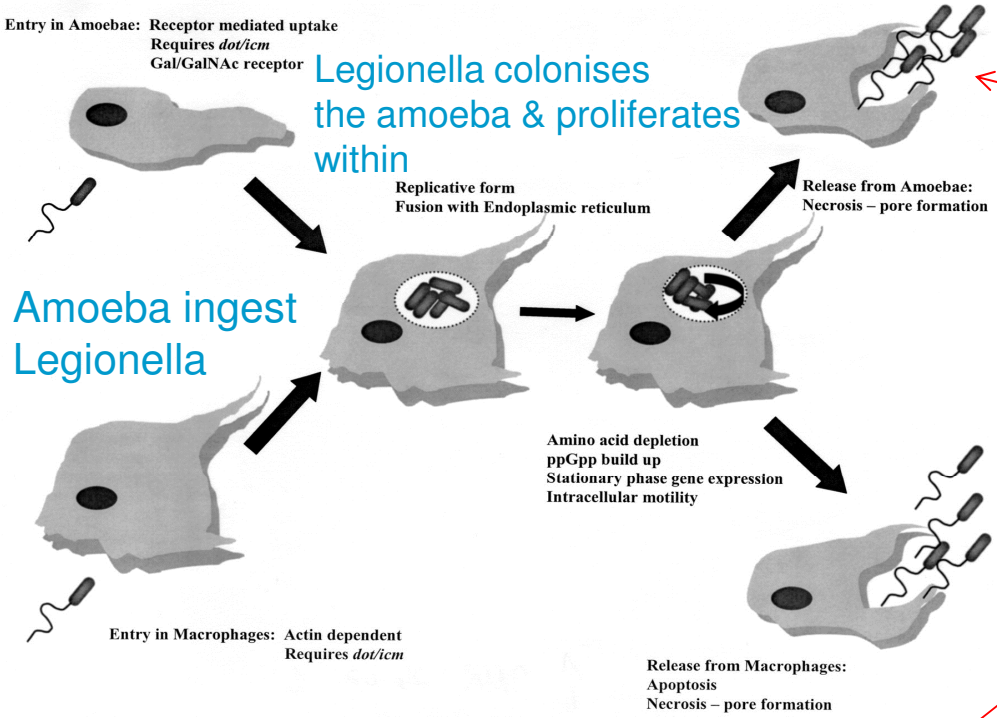
SGTPL

•Summary

Metal Ions + SORA Natural Ceramic + Repulsive Ferrite M

1. Ag^{+} and Cu^{2+} exhibits high and long lasting biocidal and algicidal effect 2. Penetrate bio-film & prevent bio-film & bio-fouling formation 3. Prevent Bio-corrosion 4. Kill Legionella & other bacteria 5. Maintain energy efficiency by preventing bio-film formation	1. Unique properties to absorb unwanted metal ions 2. Enhance biocidal and algicidal effect with A^{+} & Cu^{2+} ions 3. Make water cluster smaller 4. Improve water scale dissolution capacity – de-scaling 5. De-oxidizing effect and deter rust formation 6. Maintain energy efficiency 7. Save water	1. Increase the dispersibility of metal ions that lead to acceleration of water cleansing action and de-scaling 2. Minimize crystal accumulation at electrodes to maintain good ion generation

Microorganism – Amoeba & Legionnella



Legionella colonises the amoeba & proliferates within

Amoeba ingest Legionella

Amoeba burst & releasing huge number of legionella into the water

This can then be transported to an outlet and disseminated into an aerosol sized droplets. Inhalation of these droplets leads to Legionaires Disease.

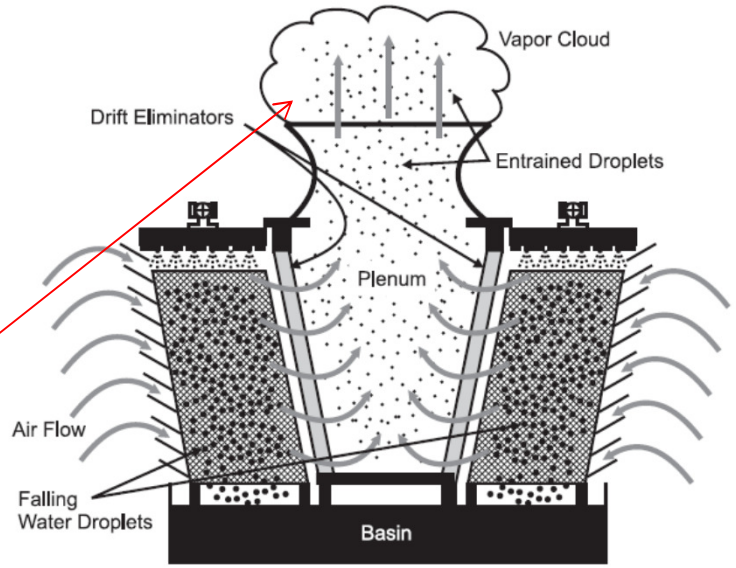
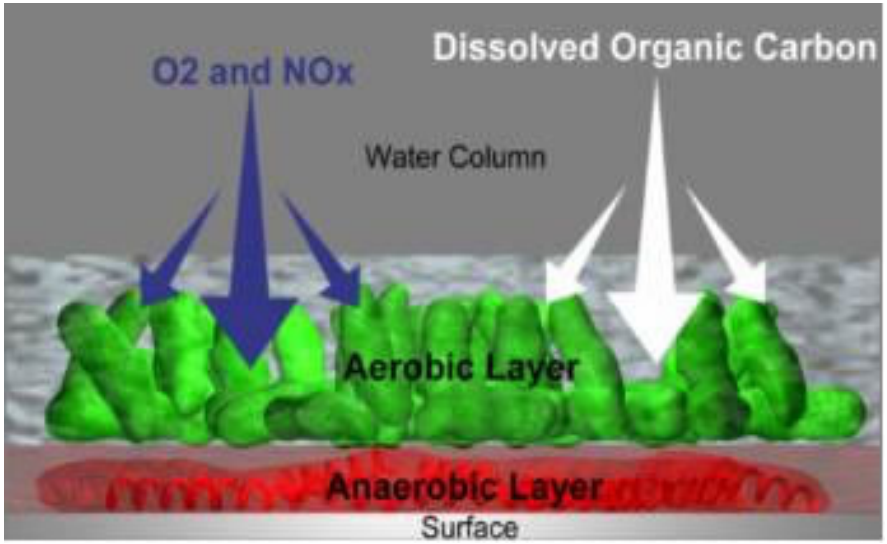


FIGURE 18.2 The small water droplets that escape the drift eliminators are known as drift. If *Legionella* bacteria are present in the tower water, the drift can carry the bacteria out of the cooling tower. The condensed vapor cloud from the evaporated water is not drift and does not carry the bacteria.

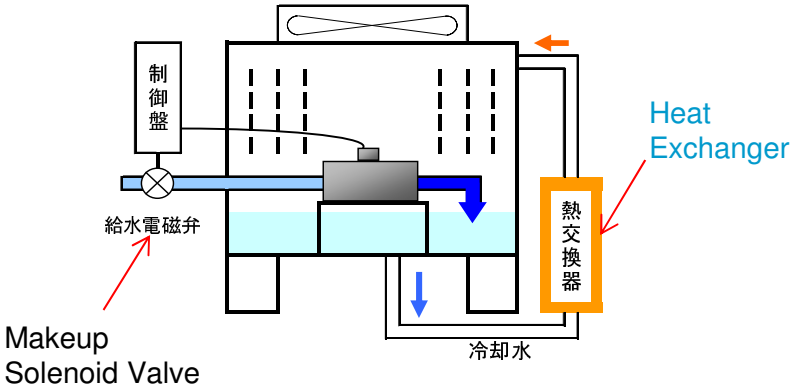
Bio-Corrosion

- **Biofilm → Biofouling → Bio-corrosion**
  - Biofilm is sticky and trap chemical precipitation, organic flakes, death cell mass and lead to Biofouling
  - Cooling tower water is constantly being aerated, resulting in fresh supply of oxygen supply to aerobic bacteria
  - Anaerobic bacteria flourish under deposits from biofouling and in stagnant areas of the system can cause severe localized pitting and corrosion and increase frictional drag (wastage of energy)



Biofilm

Anaerobic sulfate reducing bacteria can form and live underneath Biofilm and produce sulfuric acid which will corrode pipes and results in leaks. Anaerobic iron-oxidising bacteria can cause serious corrosion to pipes, heat exchangers and fitting



Out of Water Model Schematic

Another Out of Water Model Installation

Control Panel

Sora System help to conserve water usage

SGTPL

- Cooling tower water becomes concentrated due to water loss thru evaporation and this will lead to scale forming when the water reaches saturation level
- Automatic control is installed to auto-blowdown when the conductivity level reaches a preset setting
- Fresh makeup water is regularly supply to replenish the water loss thru evaporation and blowdown
- Fresh water replenishment will dilute chemicals and additional chemical has to be poured in to preserve the effectiveness of treatment
- Sora Systems activate water itself to prevent scale buildup and sterilize water with metal ions; this means that operation with high-concentrated water is possible, leading to a saving of replenishment of water
- Link to Water Saving Calculator with Sora System
- Link to Singapore Green Mark - Water Efficient NRB 2-4(a) Pg 148

Sora Non-Chemical Water Treatment System

SGTPL

- **Benefits of SORA System over conventional chemical treatment**
  - Eliminates the need for any chemical treatment, handling, movement or storage (flammable, toxic, corrosive, double containment required). Safe and ECO friendly (1 point for Green Mark)
  - There is no threat to personnel – use of chemicals require safety regulation compliance and tedious logistic arrangement
  - There is no special handling with special protection – only require simple cleaning to wipe clean the electrodes
  - Excellent scaling, corrosion and biological controls and capable of maintaining optimum efficiency of equipment thus reduce energy wastage
  - Water saving since system is capable of running at higher cycle of concentration (7 cycles as minimum recommended by NEA. 1 point for Green Mark). Promote lower cost of ownership and financial benefit

    Link to water saving from customer
  - Excellent for Corporate image, Green Building and ISO14000 qualification

Purpose of Cooling Tower Water Quality Control

SGTPL

- **Control microorganism to minimize health risk**
  - Sora System consistent excellent performance is proven with thousands of lab test results
- **Control scaling & inhibit biofilm growth to maximize heat transfer efficiency & avoid energy wastage**
  - Pumping energy thru reducing drag in pipes & blockage in strainers & heat exchanger
- **Minimize corrosion to prolong equipment life span, prevent localize damage and breakdown**
- **Cost savings thru non-usage of chemical, less water & less energy**

Current Issues with Chemical Cooling Tower Biological Control

The warm water that enters wet cooling towers contains dissolved and suspended solids, making it an excellent medium for the growth of microorganisms such as bacteria & algae .

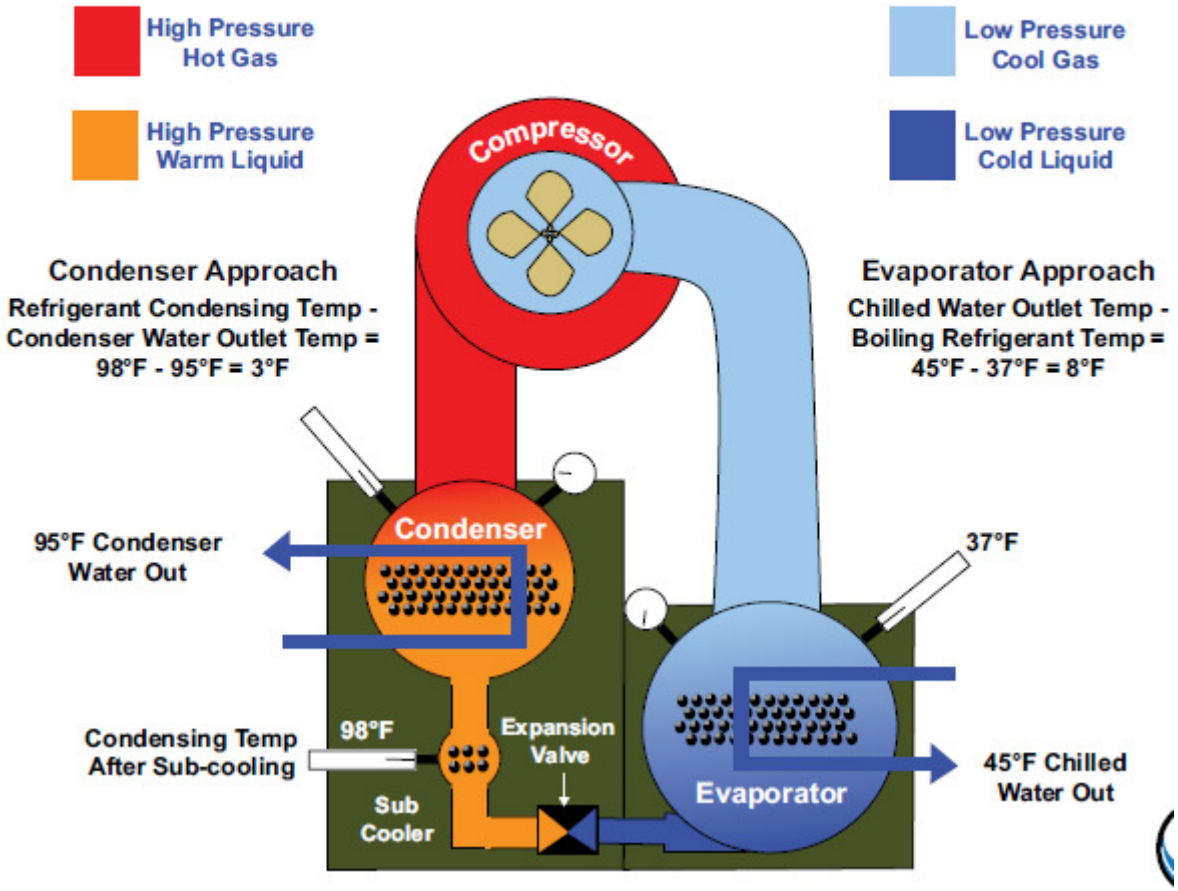
Chemical Product	CAS Number	Acute OralToxicity (rat LD 50)
Glutaraldehyde	111-30-8	134 mg/kg
Isothiazolin	26172-55-4	57.2 mg/kg
Dithiocarbamate	142-59-6	395 mg/kg
Bromochlorohydantoin	32718-18-6	877 mg/kg
Dibromo Propionamide	10222-10-2	308 mg/kg

Many commonly used oxidizing and nonoxidizing biocides can present a worker hazard due to their toxicity.

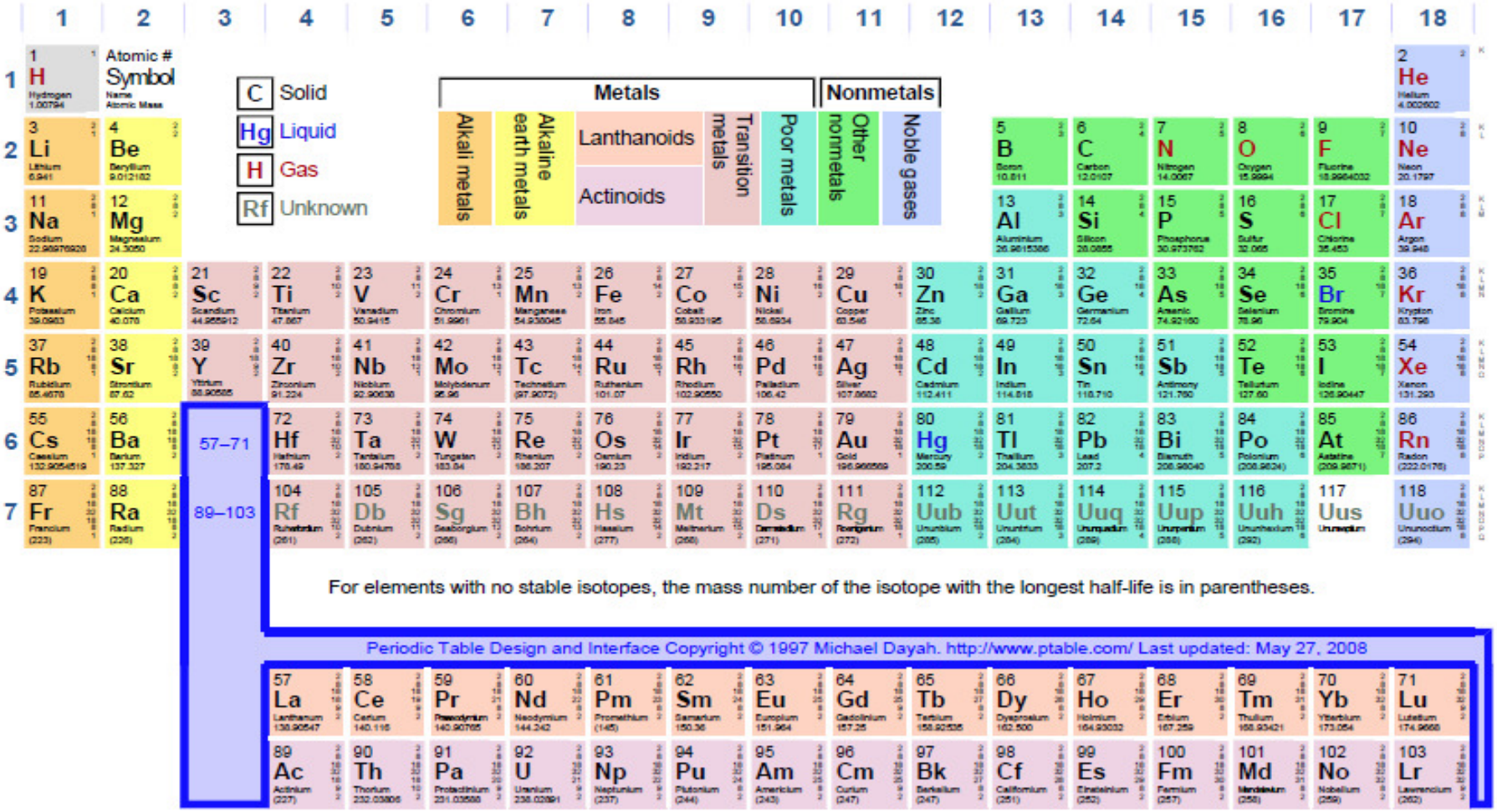
Biocide Product	CAS Number	LC 50 Aquatic Toxicity	Typical Dosage
Glutaraldehyde, 25%	111-30-8	Rainbow Trout, 56.2 ppm Daphnia, 16.9 ppm	130 to 650 ppm
Isothiazolin, 1.5%	26172-55-4	Rainbow Trout, 0.14 ppm Daphnia, 0.13 ppm	35 to 883 ppm
Dithiocarbamate, 30%	142-59-6	Rainbow Trout, 0.10 ppm	40 to 120 ppm
Bromochlorohydantoin, 98%	32719-18-6	Rainbow Trout, 0.42 ppm	12 to 72 ppm
Dibromo Propionamide, 20%	10222-10-2	Rainbow Trout, 2.3 ppm	25 to 100 ppm
Polyquat, 20%	7173-51-5	Bluegill Sunfish, 1.6 ppm Daphnia, 0.47 ppm	5 to 315 ppm

Both oxidizers and nonoxidizers are extremely toxic to most aquatic life, and even small product spills and leaks can produce catastrophic effects.

Condenser and Evaporator Approach Temperature



Periodic Table of Elements



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