IOMSA 2008

New Technology Reduces Water Use and Permits Recycled Water Application in Cooling Towers

Report by Dan Duke
Water Conservation Technology International

This presentation posted as report on WCTI website:
water-cti.com

Presentation Outline

- Water Sustainability & Cooling Towers
- New Corrosion / Scale Control Chemistry
- New Technology Benefits
- Steel Mill ZBD Case History
- Waste Water Reuse

Definitions

- TDS = total dissolved solids (ions in water)
- TSS = total suspended solids (particles not dissolved)
- COC = concentrations of chemical ion
- ZBD = zero blowdown from cooling tower
- HES = high efficiency softening
- Makeup = water used for tower evaporation plus blowdown waste to sewer
- ROI = return on investment

Sustainability Issues

- Fresh water supply is diminishing for nature, irrigation, population, industry
- Discharge of organics and toxicants into ecological water sources must be limited
- Future water and discharge regulations, increased use cost, will restrict industry
- Conserving supply of usable water and energy sources is critical to everyone

What Cooling Towers Do

- Their primary purpose is to reduce water use
- They evaporate pure water into biosphere to remove heat from cooling systems
- They consume second largest quantity (~5%) of fresh water use after irrigation
- They concentrate minerals in source water and typically discharge 20-40% of makeup to sewer
- They discharge organic chemicals and biocides used for scale, corrosion and bio control

Limitations with Traditional Cooling Tower Treatment

Limit	**Impact**	***Control Mechanisms***
1. Ca/Mg	Scale	Blowdown / Inhibitor / Acid
2. Silica	Deposits	Blowdown / Inhibitor
3. TDS	Corrosion	Blowdown / Inhibitor
4. pH	Corrosion & Scale	Blowdown / Acid

What If

- You could replace 20 to 40% of the fuel in your vehicle tank with water …
- get the same gas mileage …
- and eliminate toxic exhaust emissions!

You Can in Cooling Towers

- Evaporate over 98% of water used.
- Reduce tower water use 20-40% *(9,000 to 24,000 GPD water wasted per 1000 tons cooling load)*
- Eliminate use and discharge of chemicals
- Eliminate energy loss from scale
- Virtually eliminate corrosion of metals
- Reduce water, sewer and chemical costs

New Corrosion & Scale Control Chemistry

Four US Patents; # 6,929,749;

6,949,193; # 6,998,092; # 7,122,148

Additional Patents Pending

How Chemistry Works

- Pre-treat removes low solubility ions (Ca/Mg)
- Eliminates scale limitations in towers (100X)
- Other TDS very soluble (Evap Cooler 800X)
- Soluble silica polymerizes at > 200 mg/L
- Polymerized silica protects metals from TDS
- Excess silica forms amorphous colloids
- High TDS/pH prohibits bio & pathogen growth

Hard Water / Traditional Chemistry
Major Ion Relationships @ 2-5 COC

Metal Cations		Anions
Ca^{+2} (60%)		Cl^{-}
Mg^{+2} (30%)	SiO_2	SO_4^{-2}
Na^{+} (10%)	⟺	CO_3^{-2}
		OH^{-}

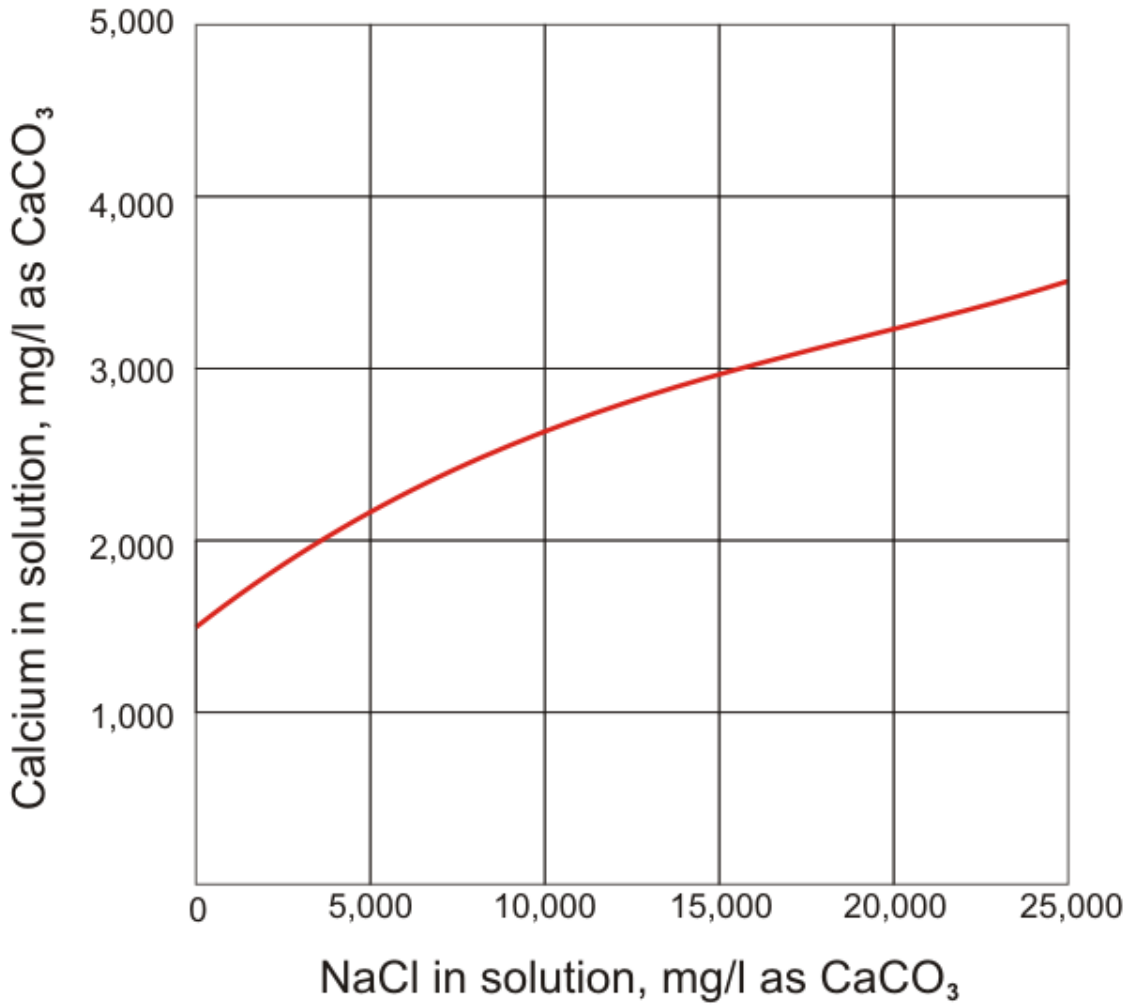
Softened Water / High TDS Chemistry
Major Ion Relationships @ 20-800 COC

Metal Cations		Anions
-		Cl^-
-	SiO_2	SO_4^{-2}
Na^+ (99%)	⟺	CO_3^{-2}
		OH^-

No Scale due to High Solubility of Sodium Salts (@ 30º C)

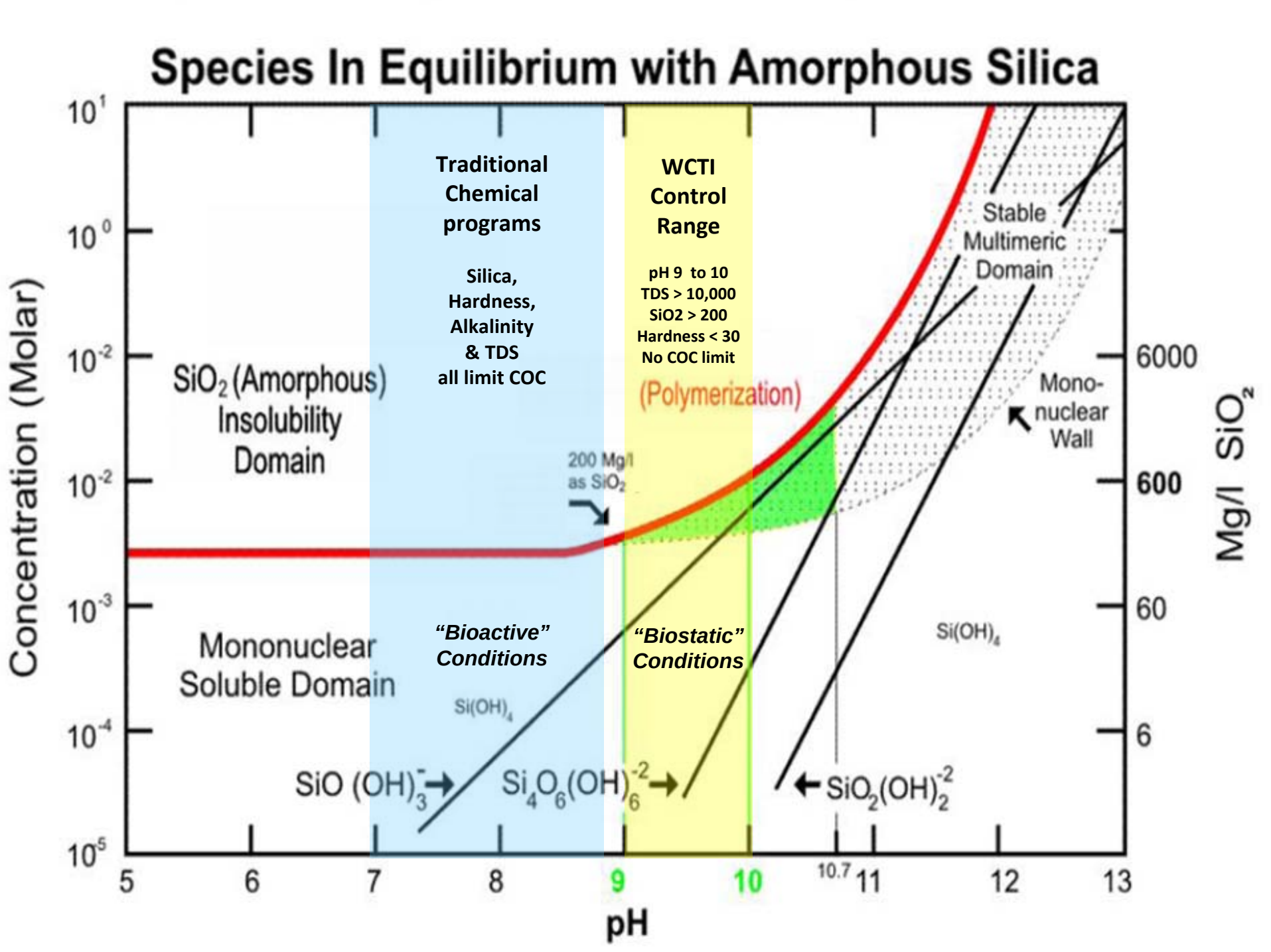
- ZBD Towers – all ion pairs as sodium salts
- Sodium Chloride (35.7% ~ 357,000 mg/L)
- Sodium Carbonate (16%)
- Sodium Sulfate (48%)
- Sodium Ortho-Phosphate (25.8%)
- Non-common ion effect (example, higher calcium solubility in seawater)

Calcium sulfate (gypsum) solubility increases with increasing sodium chloride.

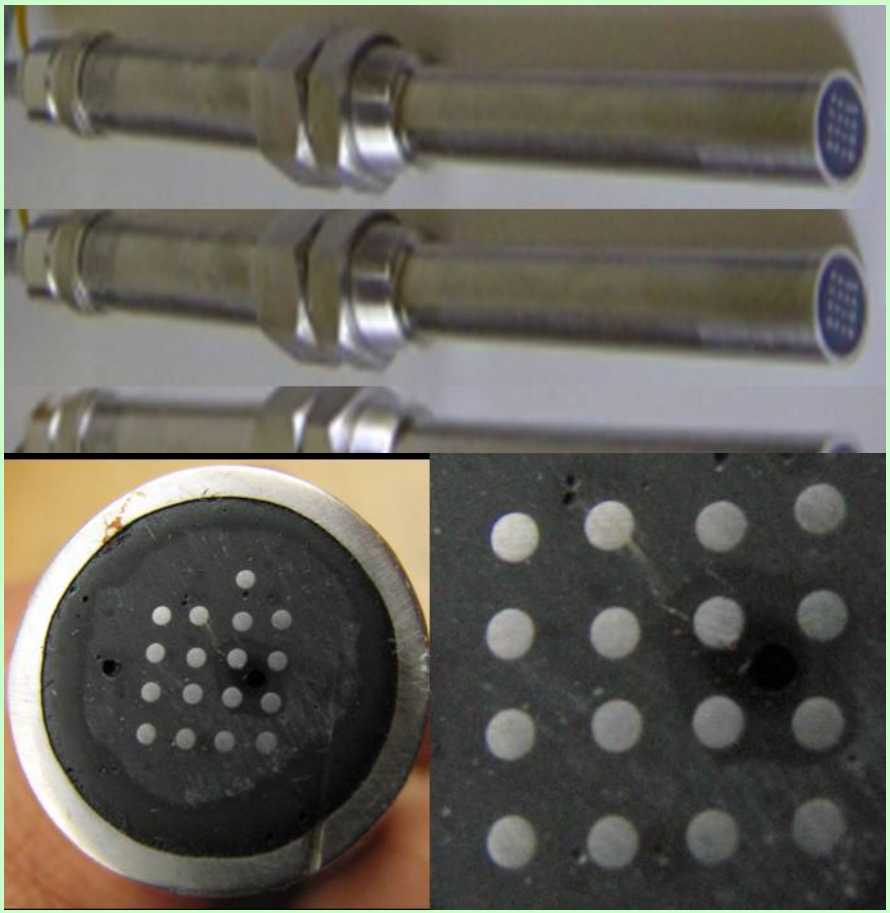


Soft Water / Silica Corrosion Inhibition Chemistry

- Only requires HES softened makeup
- Natural alkalinity and silica in source water
- Not affected by low or high TDS
- Not affected by ammonia, soluble organics
- Control chemistry strips ammonia
- No failures in five year life; used in steel, auto, food, aerospace, data server applications.

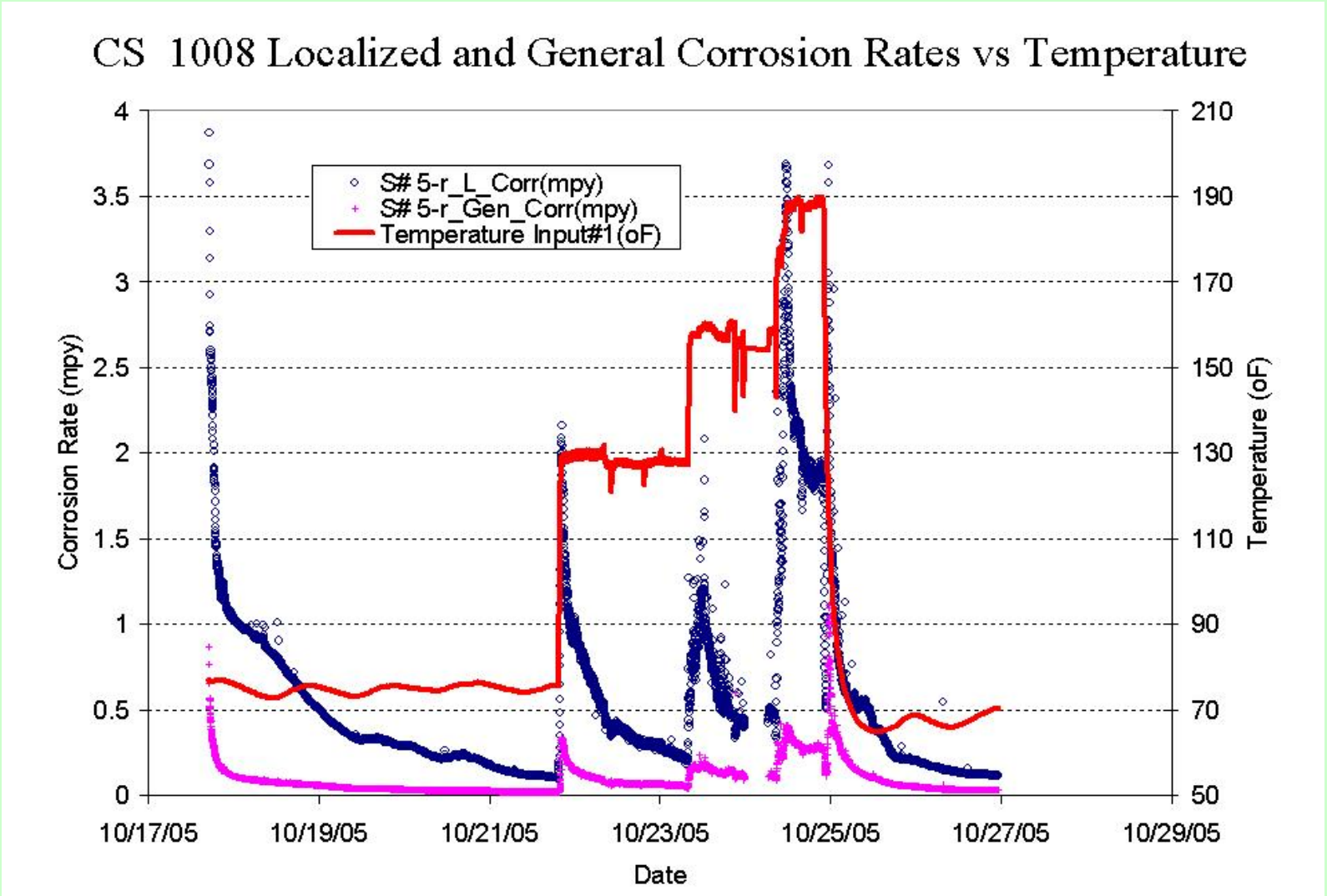

Species In Equilibrium with Amorphous Silica
Traditional Chemical programs
Silica, Hardness, Alkalinity & TDS all limit COC
WCTI Control Range
pH 9 to 10
TDS > 10,000
SiO2 > 200
Hardness < 30
No COC limit
(Polymerization)
Stable Multimeric Domain
Mono-nuclear Wall
SiO_2 (Amorphous) Insolubility Domain
200 Mg/l as SiO_2
Mononuclear Soluble Domain
"Bioactive" Conditions
"Biostatic" Conditions
$Si(OH)_4$
$SiO(OH)_3^-$
$Si_4O_6(OH)_6^{-2}$
$SiO_2(OH)_2^{-2}$
Concentration (Molar)
Mg/l SiO_2
pH
10.7

High Temperature Corrosion Inhibition Studies



- Used real time coupled multi-electrode array corrosion probes
- Probes measured peak localized and general corrosion rates
- Test water chemistry:
  - 50,000 TDS / conductivity
  - 450 ppm silica
  - 9000 ppm chloride
- Temperatures:
  - 77^{o} F; 130^{o} F; 160^{o} F; 190^{o} F **(25^{o} C; 54^{o} C; 71^{o} C; 88^{o} C)**
- Metals:
  - CS1008; 316L SS; AL1100; Cu 1100; Zn

Silica Inhibited Study / High Temp

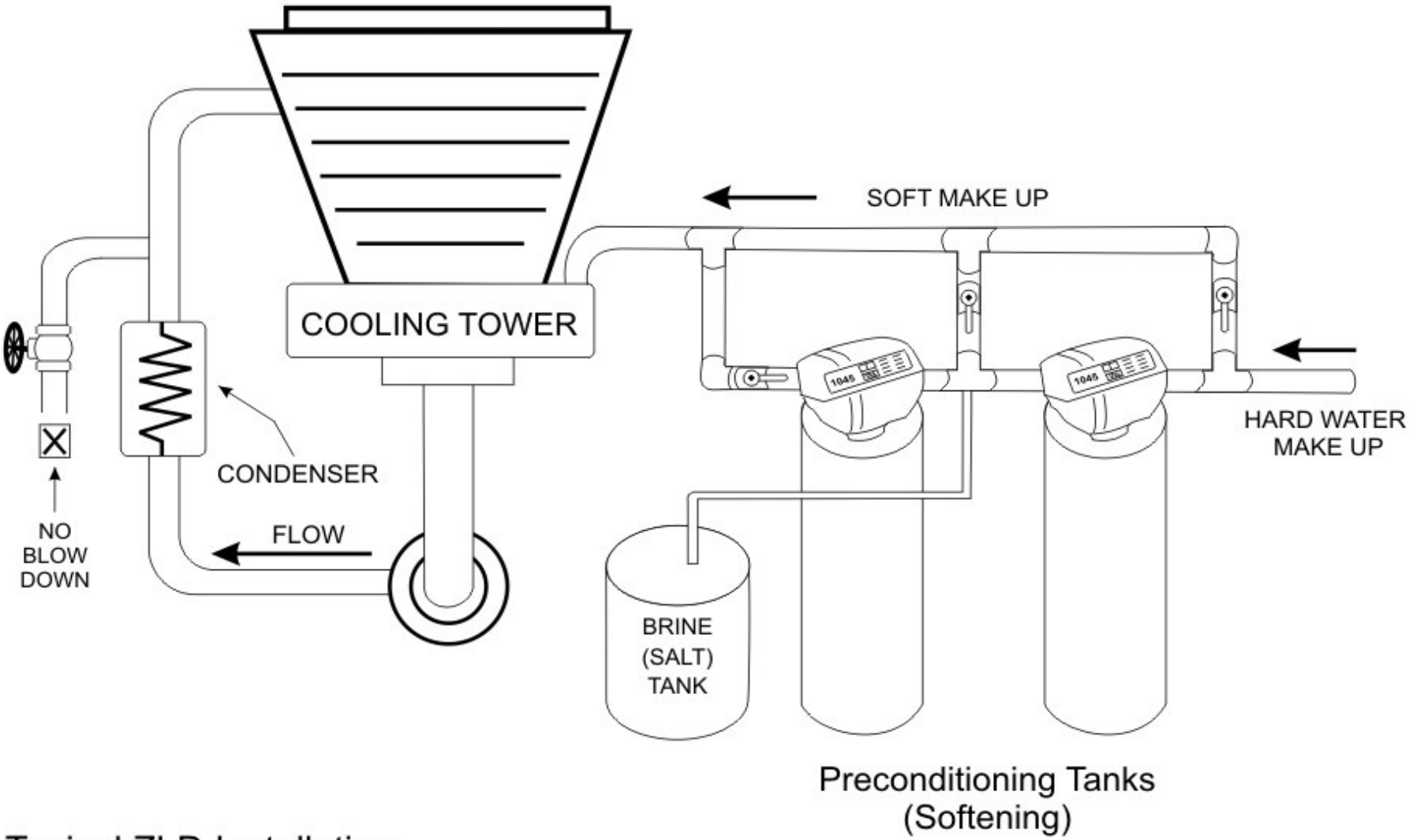


Natural Biostatic Chemistry

- Elevated pH and TDS are naturally biostatic to bacteria, spores and viruses
- Hydrolysis of peptide chains as water pH is increased (used in waste treatment)
- Denaturing of proteins or enzymes by elevated TDS
- Report by Anderson Engineering
- Natural pH/TDS increase with tower water evaporation at elevated COC (or ZBD)

New Technology Benefits Water Conservation

- ZBD reduces water use / blowdown by 20-40%
- Blowdown and pH control systems not required
- Chemical storage and feed systems eliminated
- Discharge of organics and toxicants minimized
- HES only removes scale ions (Ca & Mg), very cost efficient and very low waste volume (Lean)
- Excellent ROI with HES equipment (< 12 months)
- ZBD now cost effective for any cooling tower
- Cost less than traditional chemical treatment



Typical ZLD Installation

HES – ZBD Equipment Economy

- Low regenerate use / high efficiency softening (HES) design @ 4# / CF resin
- Typical salt usage cost of $0.12 per 1000 gallons vs $2.00-5.00 water / sewer cost
- Total cooling system discharge reduced from 20-40% to 1-2% of makeup water
- Equipment and operating cost is 15% of conventional ZBD water recovery systems

1000 Ton Load Example p1

System Design Information	Current	Proposed
Cooling - Design Capacity Tons	**1500**	1500
Cooling - Peak Load Tons	**1200**	1200
Cooling - Average Load Tons*	**1,000**	1,000
Average Load Evaporative GPM	25.0	25.0
Cycles of Concentration	**2.5**	**50**
Blowdown GPM	16.0	0.5
Make-Up GPM	40.0	24.5
Avg Raw Total Hardness, mg/L CaCO3	**200**	0.5
Cost of Make-up per 1,000 Gals.		**$ 2.00**
Cost of Blowdown per 1,000 Gals.		**$ 1.00**
Current Annual Water Use	Gallons	21,024,000
Proposed Annual (Reduced) Water Use	Gallons	12,871,837
Annual Blowdown Water Saved	**Gallons**	**8,152,163**
Water Savings (before Regenerate cost)	**$/Year**	**$ 24,066.46**

1000 Ton Load Example p2

		Regenerate Usage and Costs	
Annual Regen Water Use	Gallons/Year		130,010
Lbs. Regenerate Use / Day			91.4
Regenerate Cost $ / Lb.		**$**	**0.10**
Regenerate Cost / Year		$	3,337.14
NET ANNUAL WATER SAVINGS (less regenerate cost)		**$**	**20,729.32**
Program Costs			
Make-up Water Conditioning System Cost	CFRDA 38 HES	$	12,200.00
Installation Cost Estimate		$	1,200.00
Shipping Cost Estimate		$	800.00
Total Equipment Cost		$	14,200.00
Equipment Cost ROI (for Water Savings)	months ROI	$	8.22
WCTI Treatment Program Service Cost	Annual	$	15,000.00
Current Chemical Treatment Program Cost	Annual	$	20,000.00
Water Conservation Credit (Equipment)	Utility Name	$	24,456.49
Energy, Maintenance, other savings		$	20,000.00
Annual Potential Water, Chemical and Maintenance Savings		$	45,729.23

New Technology Benefits Reuse of Waste Water

- Maximizes use of waste heat for evaporation of waste water (minimize disposal) in cooling towers
- ZBD operation is now cost viable for any tower
- High TDS concentrations in reuse water do not affect corrosion or scale control performance
- Not affected by ammonia or organics
- Biostatic chemistry controls bio fouling in cooling system, major prior limitation for reuse water
- Total cost is 20-30% of traditional chemical treatment
- A non chemical approach that exploits natural or waste water mineral content to improve customer value (Lean)
- Qualifies as “green” program and LEED points

ZBD Case History

Steel Mill

Steel Mill Tower ZLD Water Chemistry

Cooling Tower and Soft Makeup Water Chemistry (COC) Ratios				
Sample / Tests	Tower	Filtered Tower Sample	Soft MU	COC
TDS, mg/L (NaCl Myron L 6P)	**146,000**	146,000	**251**	**582**
pH	10.07	10.07	7.58	
Copper, mg/L Cu	0.7	0.25	0.0015	
Iron, mg/L Fe	22.2	ND	ND	
Zinc, mg/L Zn	3.8	ND	ND	
Silica, mg/L SiO_2	**1,050**	1,050	**30**	**35**
Calcium, mg/L $CaCO_3$	62	12.4	<0.1	
Magnesium, mg/L $CaCO_3$	16	8.2	<0.1	
Phosphate, mg/L PO_4	**89**	-	**0.15**	**593**
Nitrate, mg/L NO_3	2590	2590	4.5	575
Sodium, mg/L Na	145,000	145,000	250	580
Sulfate, mg/L SO_4	10,260	10,260	18	570
Chloride, mg/L NaCl	**22,400**	22,400	**38**	**589**
Tot. Alkalinity, mg/L $CaCO_3$	69,400	69,400	120	578
(COC) = Concentration of Chemistry				

Steel Mill Tower #1 (24 months ZLD)
Galvanized Tube Bundle / No White Rust

Steel Mill Tower
Galvanized Coated Steel Coupon
60 Day Exposure

Mild Steel Coupons
60 Day Exposure VS Non-exposed

0.017 mpy #1652 VS 0.013 mpy #1664 (control)

Waste Water Reuse

Waste Water Makeup
for Silica / ZBD Treatment

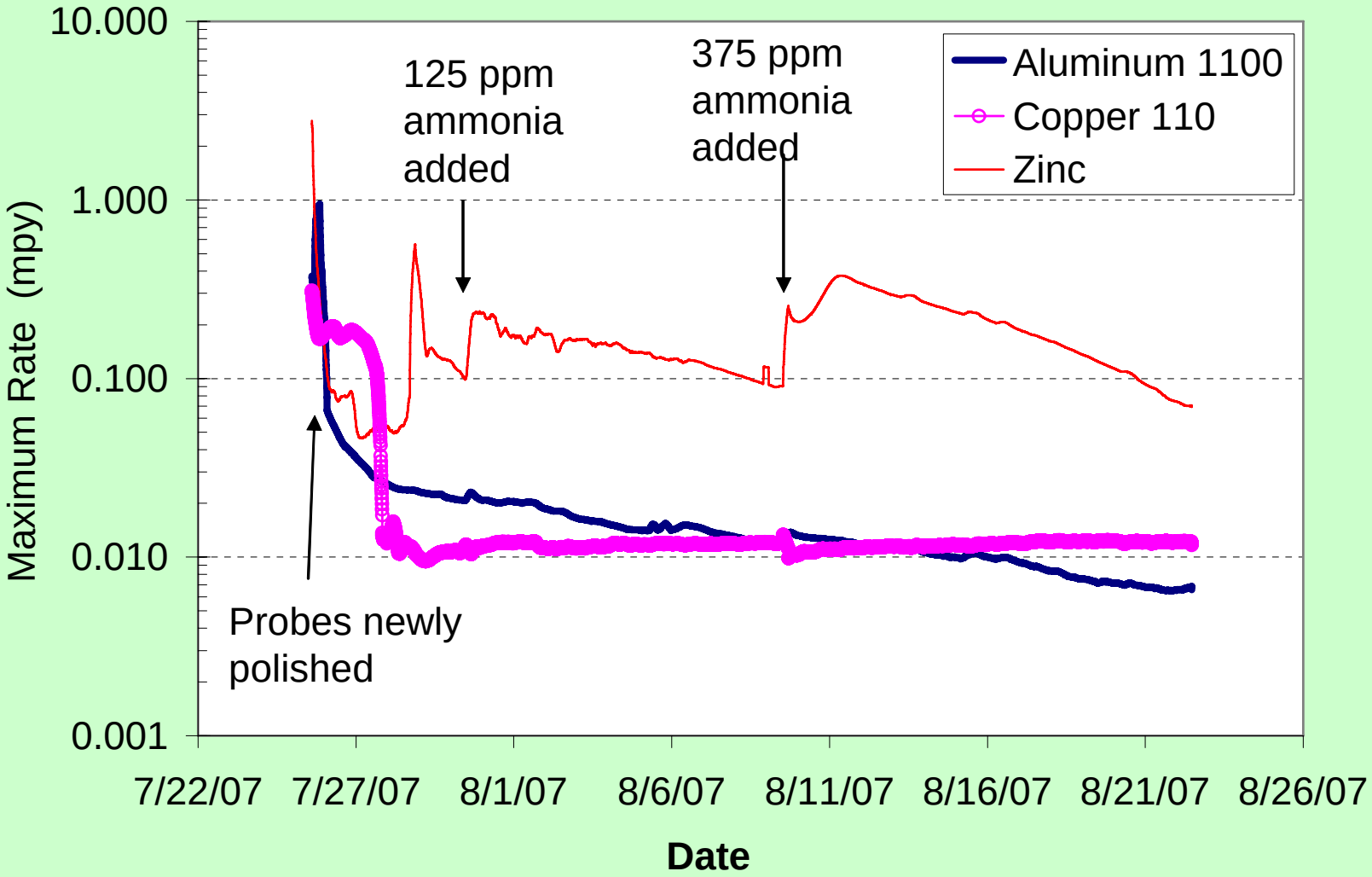
New Technology Expands Options

- Use municipal reuse, grey water, RO reject, and other high TDS water sources as makeup
- Patented method protects metals from corrosion by high TDS, ammonia, organics
- Excellent for steel, copper and aluminum
- Use lower cost system metals for economy
- Mitigates micro-biological and pathogen proliferation, reduces biocide use
- Low waste water volume if sewer discharge is not available

Reuse / Waste Water Use

- Waste water sources require filtration to remove TSS & insoluble organics.
- Suspended solids would foul the softening process and cooling system
- Higher TDS still permit ion exchange softening.
- Ammonia and soluble organics do not have to be removed with ZBD / silica chemistry.
- Tower performance equivalent for waste water or potable (fresh) water

ZBD / Silica treated Tower Water, with TTA Supplement: Ammonia Corrosion of Copper, Zinc & Aluminum Inhibited



Case History Using High Ammonia (Reuse) Waste Water

- High ammonia (38 mg/L) municipal “reuse” makeup water to 2500 ton / five tower central plant with copper chiller and absorber tubes
- Ammonia < 1 mg/L at 60 tower COC
- Ammonia attack totally inhibited with copper corrosion at < 0.1 mpy.
- Micro-biological growth from ammonia and organics mitigated (10^{o} Col / ml).

ZLD Cooling Tower using (California Title 22) Municipal Reuse Waste Water as Makeup

ZBD Tower / Soft Reuse Makeup COC Ratios (concentrations of chemistry)			
Sample / Tests (01/04/08)	Tower	Soft MU	COC
TDS, mg/L (NaCl Myron L 6P)	**66,000**	**1100**	**60**
pH	9.85	7.3	NA
Silica, mg/L SiO_2	530	20	27
Calcium, mg/L $CaCO_3$	18	0.2	NA
Magnesium, mg/L $CaCO_3$	13	0.1	NA
Sulfate, mg/L SO_4	7700	128	60
Chloride, mg/L NaCl	12500	212	59
Tot. Alkalinity, mg/L $CaCO_3$	15000	257	58
Ammonia, mg/L NH_4	**0.5**	**38**	NA
Total Phosphate, mg/L PO_4	**52**	**0.9**	58
TTA, mg/L as Tolytriazole	5	NA	NA
(COC) = Concentration of Chemistry			

Reuse Water Performance
(12 months)

- No condenser / absorber scale, approach temperatures equivalent to clean / history
- Mild steel coupon corrosion < 0.2 mpy
- Mild steel Corrator corrosion < 0.2 mpy
- Copper coupon corrosion < 0.05 mpy
- No bio growth in tower or condensers
- Zero dip stick counts / ATP testing

ZLD / Silica Program Summary

- “ZBD” operation now cost viable without risk
- Negligible corrosion at high TDS
- Use reuse or waste water makeup
- Not affected by ammonia and organics
- Mitigates biological and pathogen growth
- Simple pretreatment and control chemistry
- Reduce water use and discharge cost
- Reduce energy (loss) and maintenance costs

Questions?

LEAN / OEE

- Minimize water use and disposal costs
- Optimize energy use (heat transfer) cost
- Reduce capital expense / investment
- Reduce equipment cleaning and replacement
- Reduce variables for work flow improvement
- Reduce chemical handling and storage
- Reduce operator time and safety risks
- OEE - Optimize Equipment Efficiency

LEED (gain up to 3 points)

- ❑ Innovative Wastewater Technologies (1)
- ❑ Water Use Reduction – 10% (1)
- ❑ Water Use Reduction – 20% (1)

LOW CARBON FOOTPRINT

- ✓ Minimize heat transfer loss
- ✓ Avoid high energy consuming devices
- ✓ Eliminate manufactured chemicals