

IOMSA 2008

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

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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

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

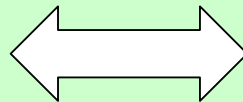
Metal Cations

Ca^{+2} (60%)

Mg^{+2} (30%)

Na^{+} (10%)

SiO_2



Anions

Cl^{-}

SO_4^{-2}

CO_3^{-2}

OH^{-}

Softened Water / High TDS Chemistry

Major Ion Relationships @ 20-800 COC

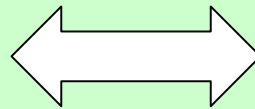
Metal Cations

-

-

Na^+ (99%)

SiO_2



Anions

Cl^-

SO_4^{-2}

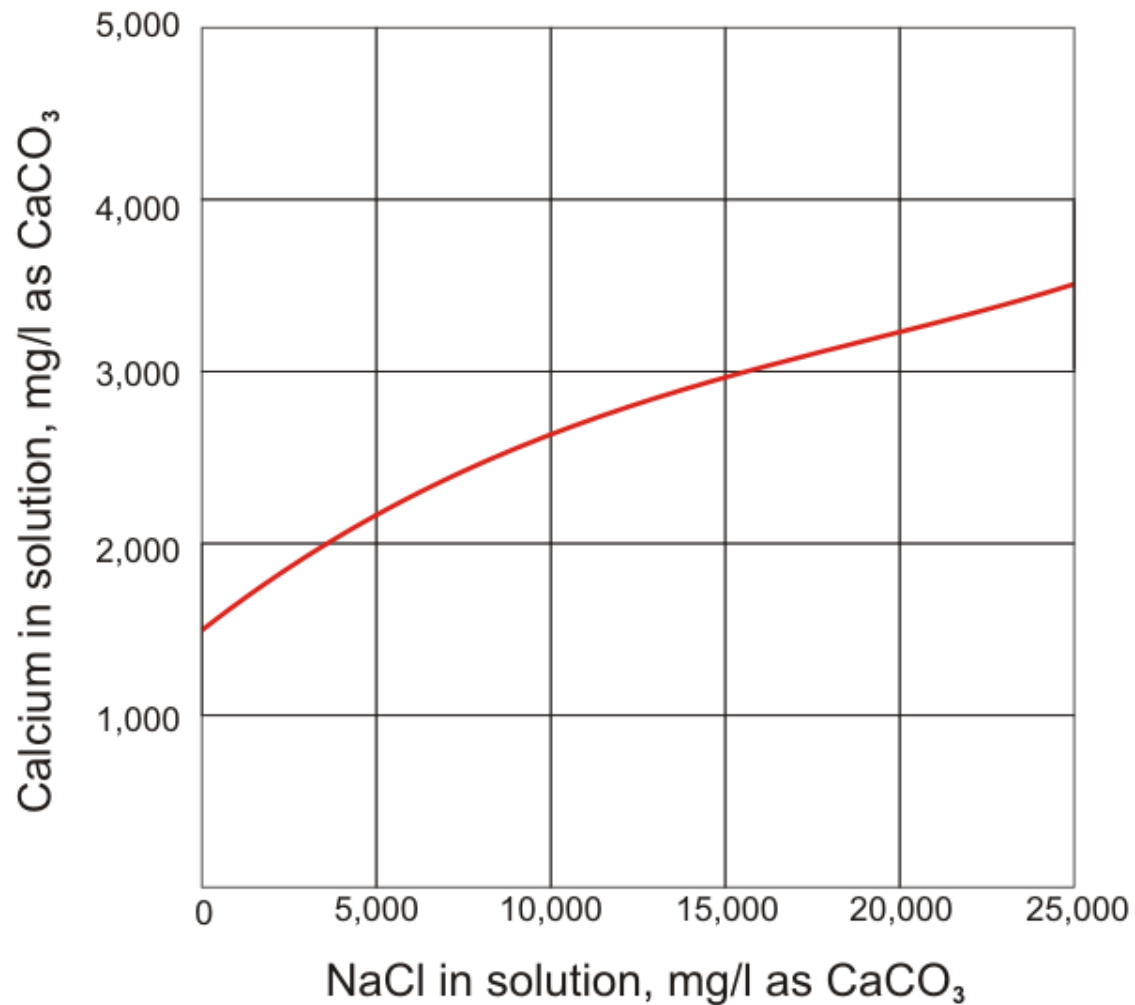
CO_3^{-2}

OH^-

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

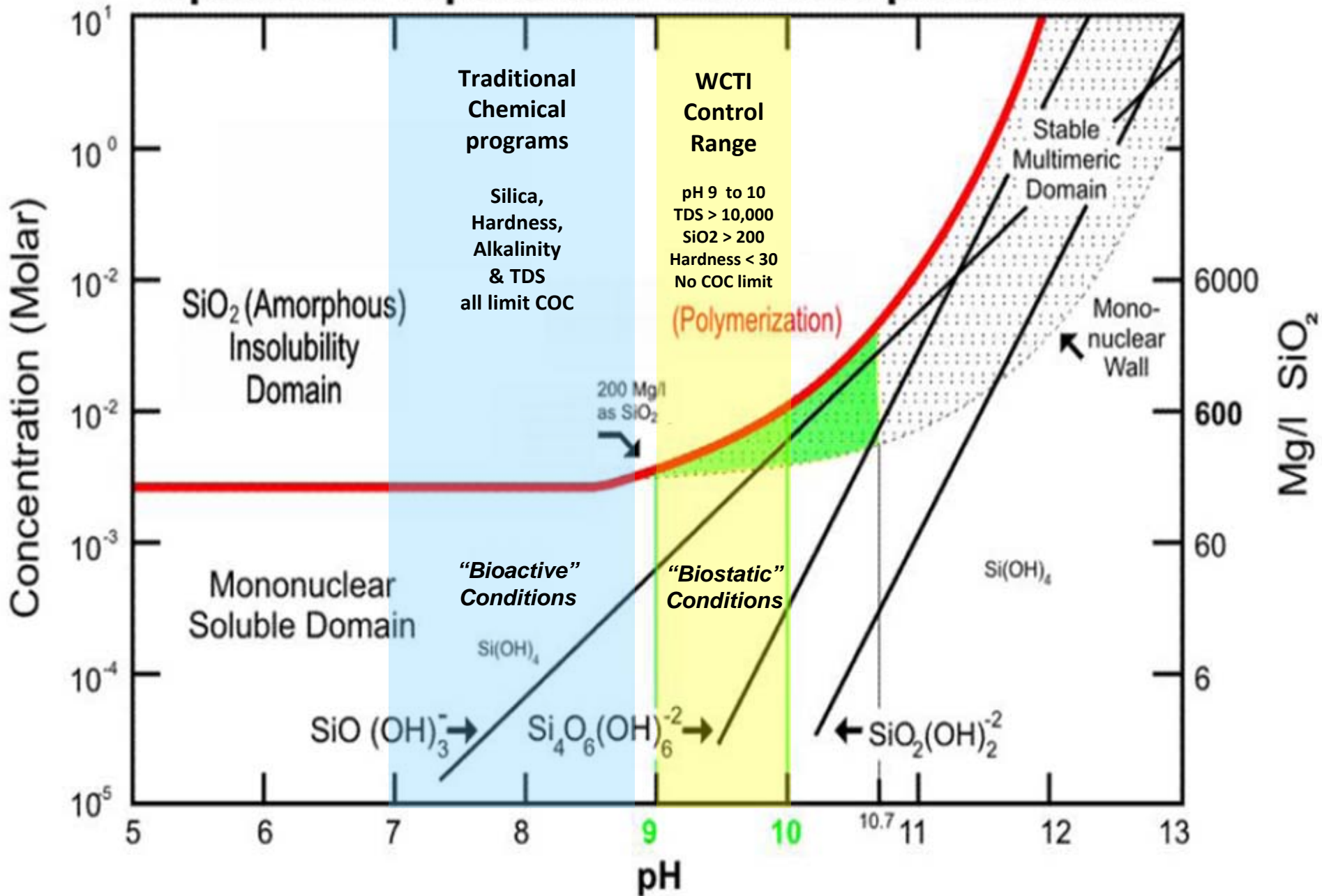
Calcium sulfate (gypsum) solubility increases with increasing sodium chloride.



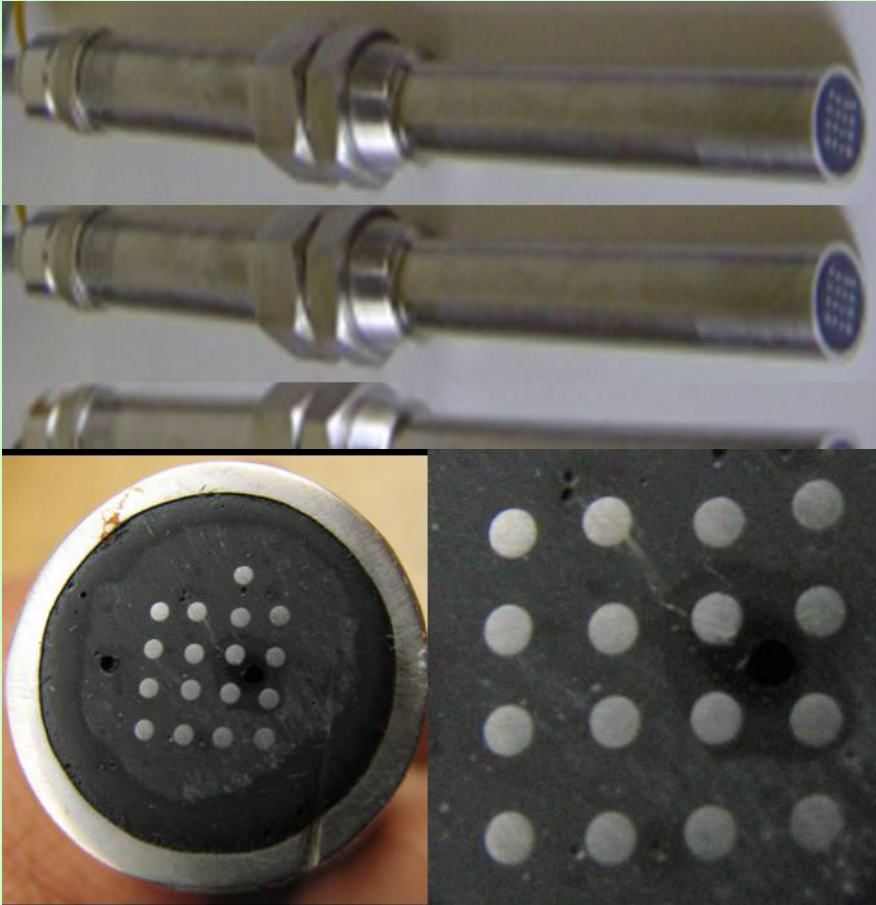
Soft Water / Silica Corrosion Inhibition Chemistry

- 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



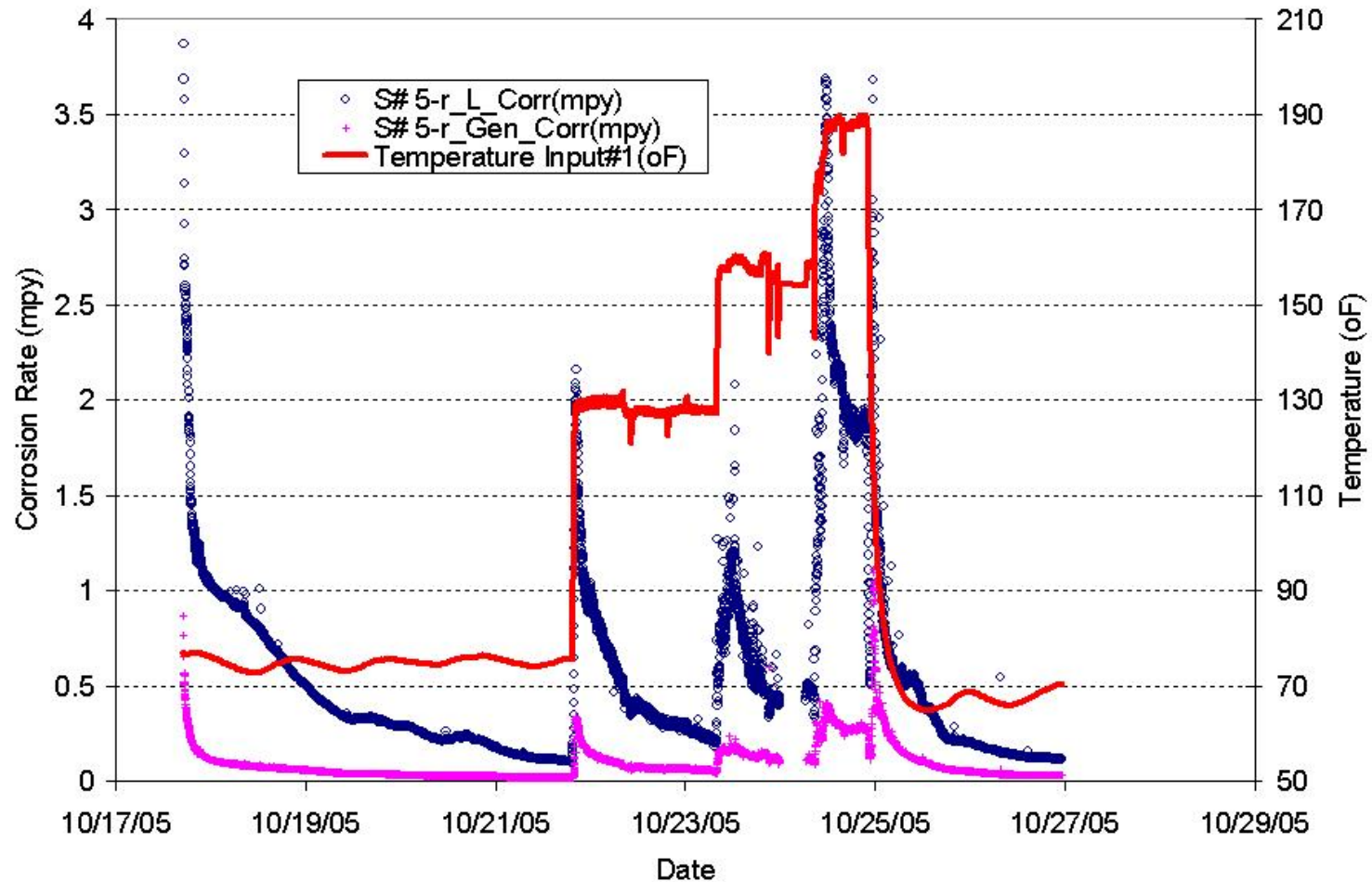
High Temperature Corrosion Inhibition Studies



- 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° F; 130° F; 160° F; 190° F
(25° C; 54° C; 71° C; 88° C)
- Metals:
 - CS1008; 316L SS; AL1100;
Cu 1100; Zn

Silica Inhibited Study / High Temp

CS 1008 Localized and General Corrosion Rates vs Temperature



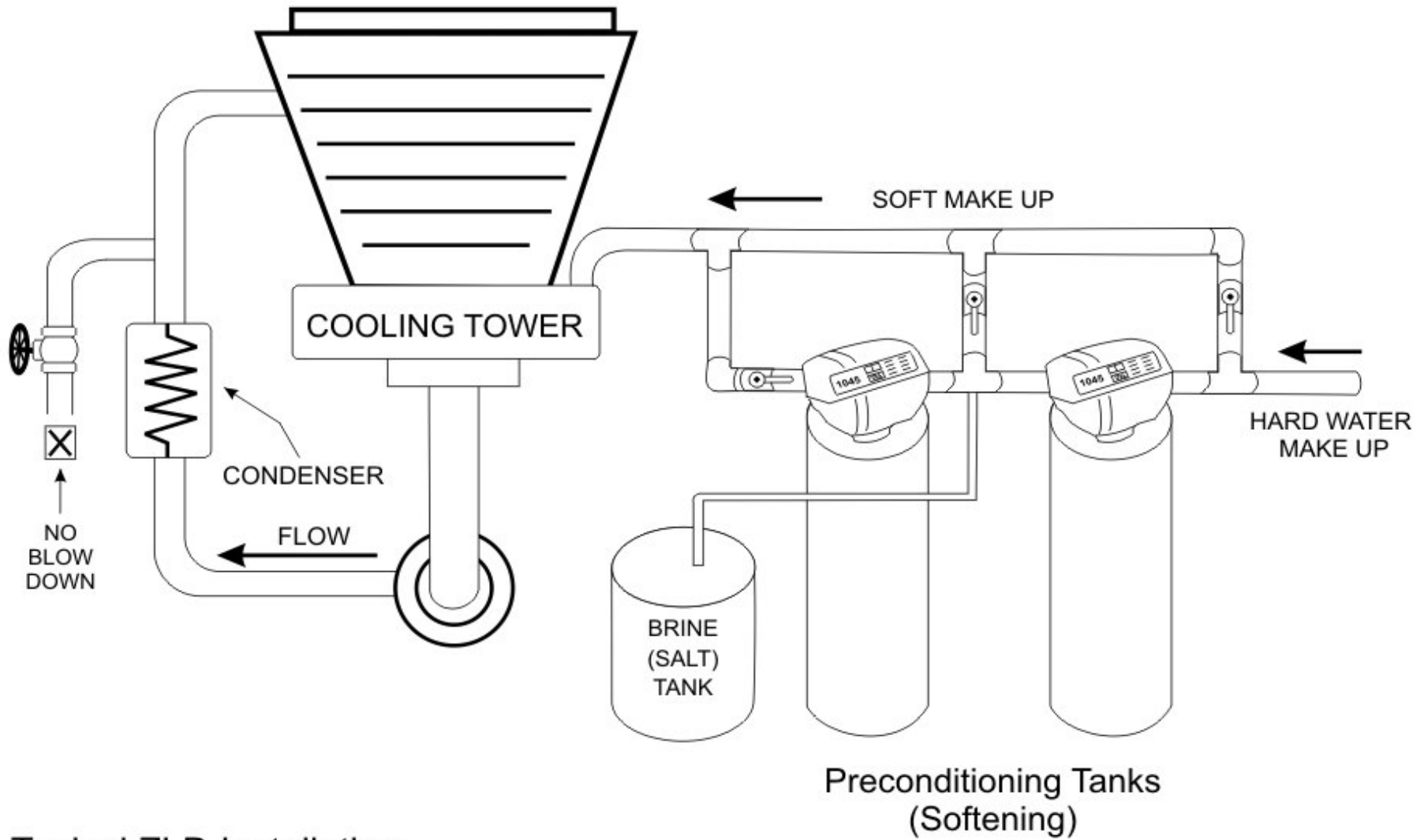
Natural Biostatic Chemistry

- 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

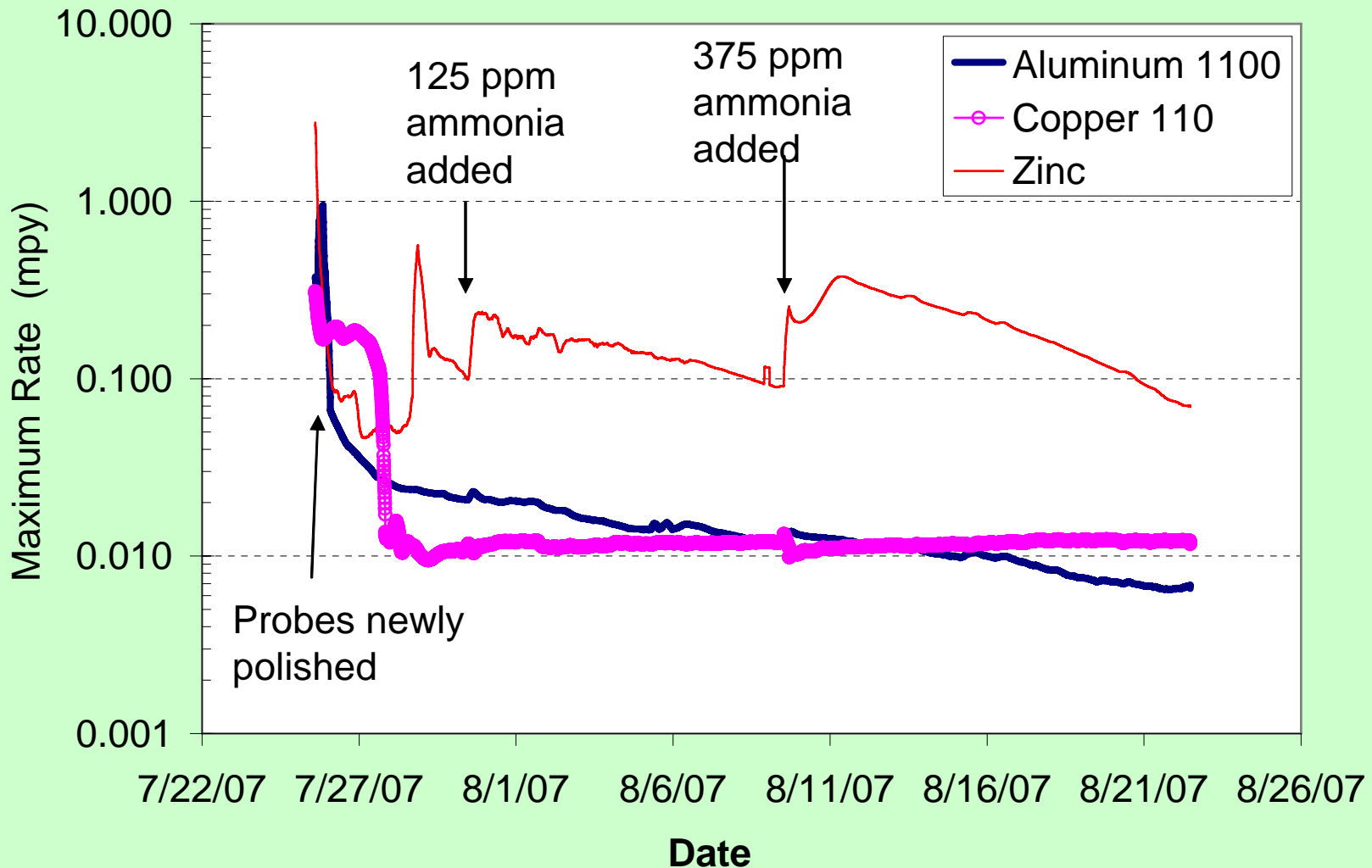
New Technology Expands Options

- 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 (10^0 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