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Zero Liquid Discharge Cooling Tower Treatment at CSI

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This technology is patent* protected;

US 6,929,749 / Silica Scale Control
US 6,949,193 / Silica Scale Control
US 6,998,092 / Corrosion Inhibition/Silica
US 7,122,148 / Corrosion Inhibition/Silica
Additional patents pending

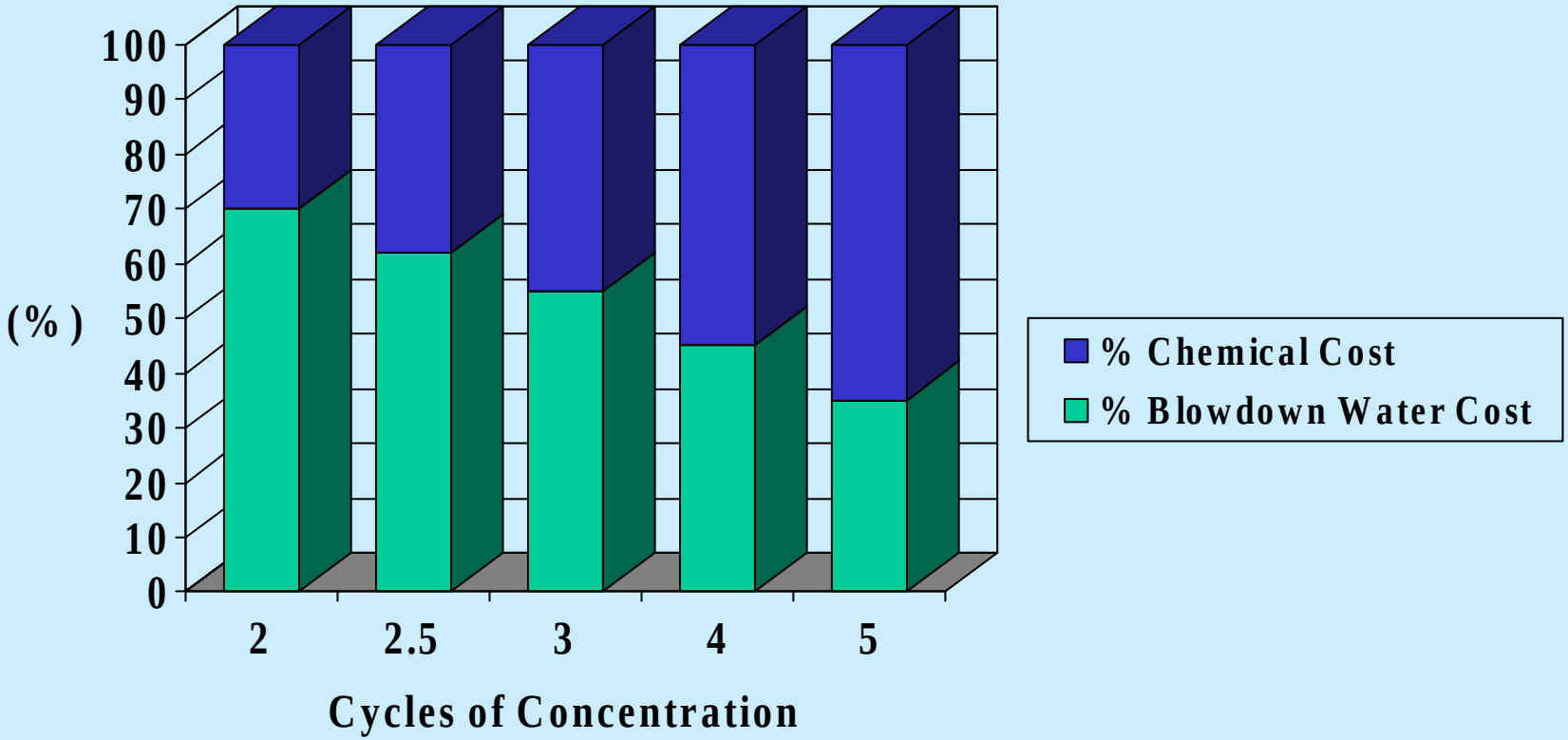
*Licensed by Water Conservation Technology International

Limitations of Current Alkaline Cooling Water Treatment

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

Blowdown Water + Chemical Cost

(Total cost of treatment)



Zero Liquid Discharge Technology

- “New Dimension” in water treatment chemistry
- High TDS / ZLD operation now cost viable
- “State of Art” corrosion & scale protection
- Total inhibition at TDS of 2,500 to >125,000
- Reduces water usage without risk of scale, corrosion, bio fouling or pathogens
- Ideal with high silica or “grey” source waters

New Chemistry Benefits

- Outstanding corrosion protection, <0.1 mpy for steel, copper, aluminum, galvanized
- Non-toxic “green” silica chemistry
- No chemical handling & storage
- Eliminates blow down discharge cost
- Reduces total treatment cost

How Silica Chemistry Works

- Proprietary pre-treatment system removes scale forming ions from make-up to tower
- Unlimited water concentrations (500X)
- Soluble silica concentrated to > 200 mg/L
- Polymerized silica protects metals at high TDS
- Excess silica polymerized to colloidal forms
- High TDS/pH prohibits bio & pathogen growth

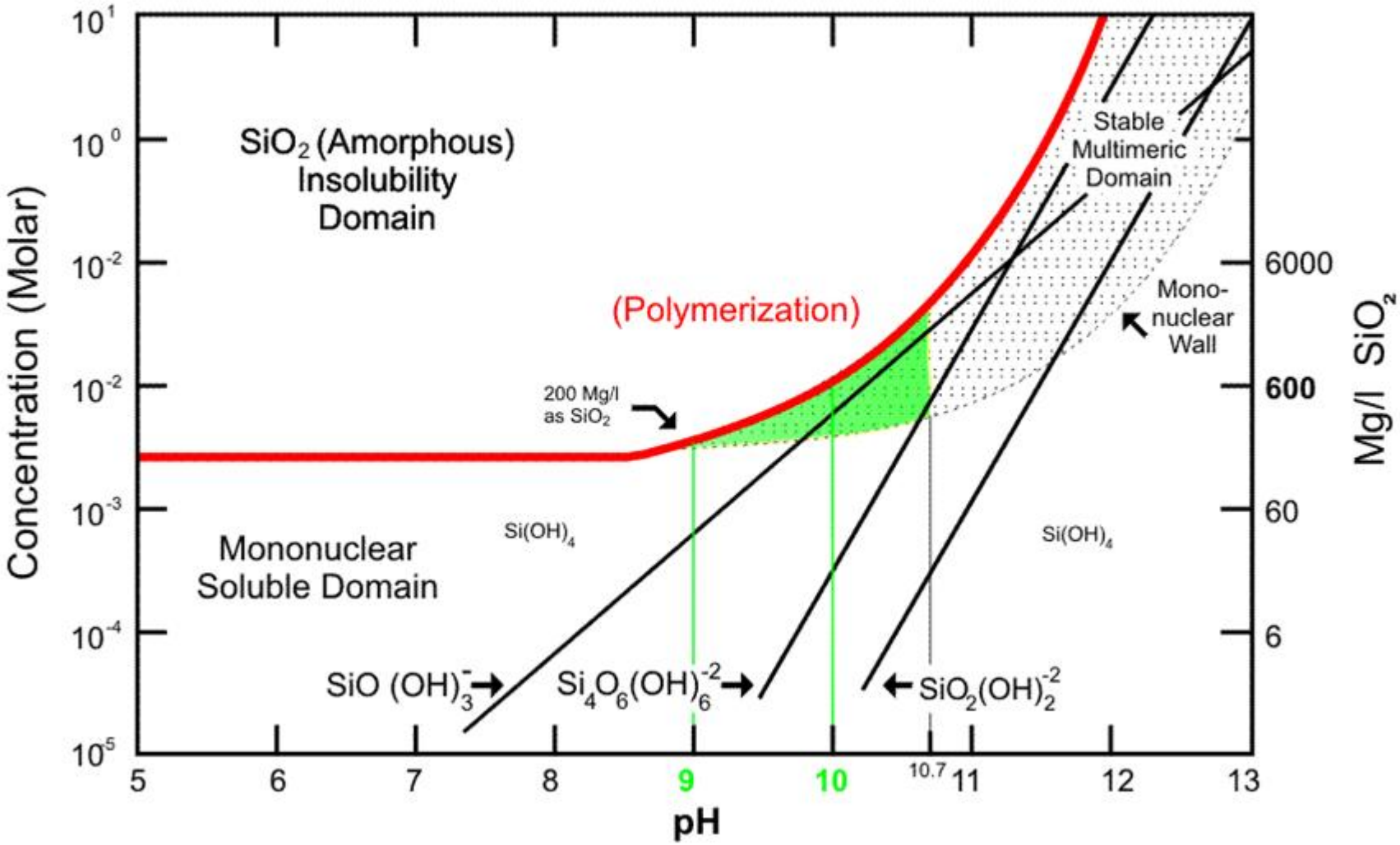
Equilibrium Chemistry

- “Alkaline” chemical programs rely on $CaCO_3$ solubility indexes in equilibrium to balance scale and corrosion potential.
- This chemistry polymerizes soluble silica to saturation equilibrium to provide superior corrosion protection and eliminate scale.

Silica Chemistry

- Removal of polyvalent metal ions from water enables silica behavior that is very different from common expectations.
- Exchanged mono valent metal ions, plus alkalinity, temperature, evaporative concentration and time polymerize silica to corrosion inhibiting species.

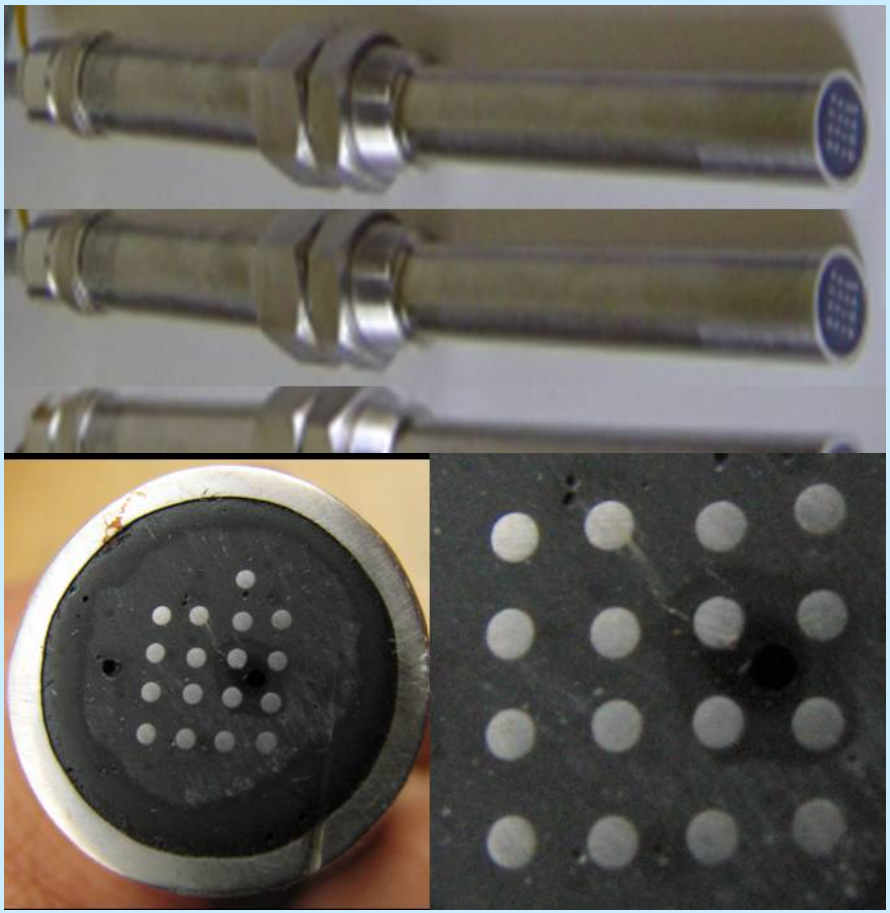
Species In Equilibrium with Amorphous Silica



Silica Cathodic Mechanism

- Saturated silicates, in equilibrium with amorphous silica, is attracted to metals
- Cathodic gel layer forms on metals for total barrier to corrosion
- Even amphoteric metals (Al, Zn) are protected by silica gel layer at high pH
- Gel layer growth is self limiting

High TDS / High Temperature Corrosion Inhibition Studies

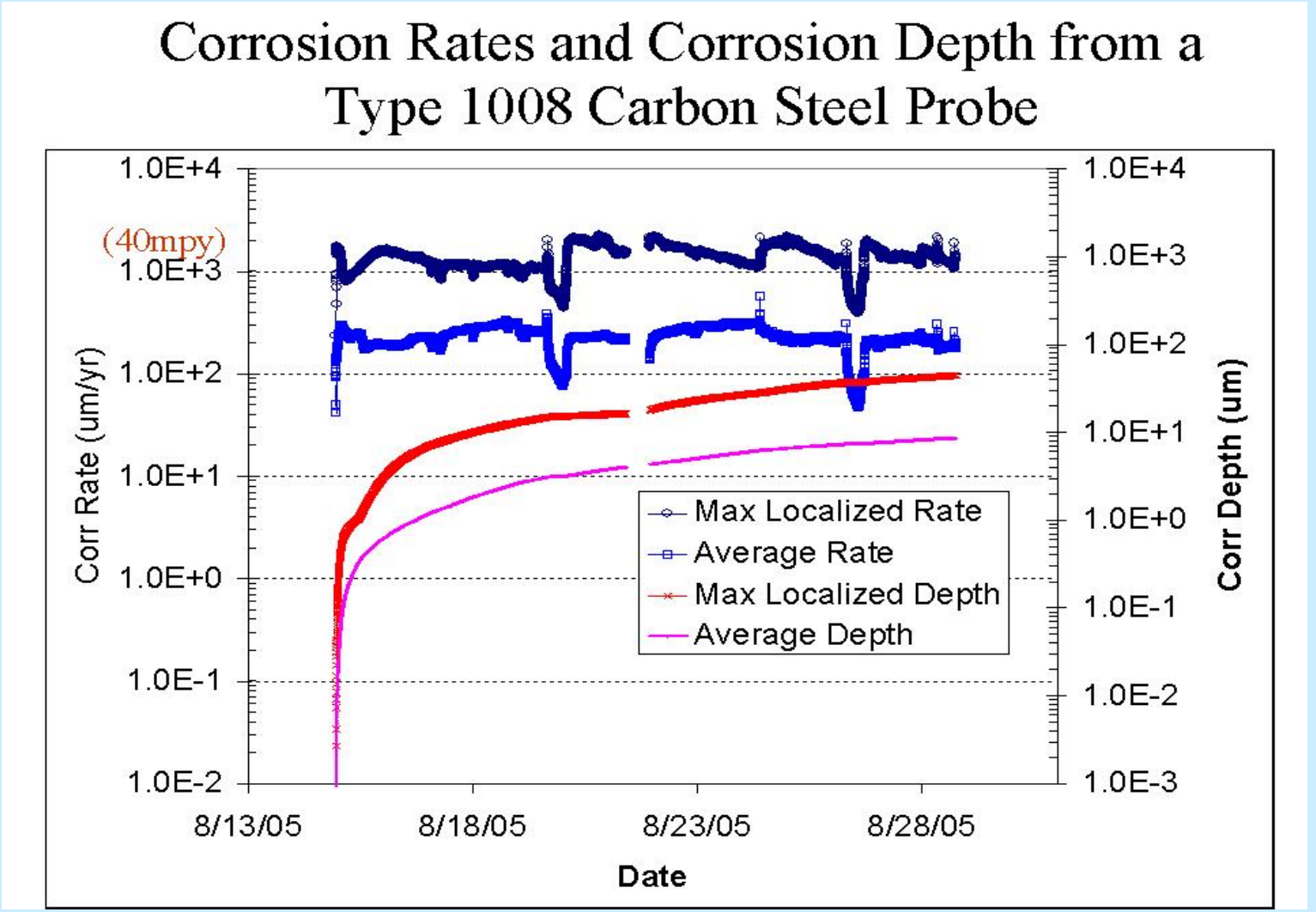


- Used real time coupled multi-electrode array corrosion probes
- Probes measured peak localized and general corrosion rates
- Test water chemistry:
  - 50,000 conductivity
  - 450 ppm silica
  - 9000 ppm chloride
- Temperatures:
  - 77^{o} F; 130^{o} F; 160^{o} F; 190^{o} F **(25^{o} C; 54^{o} C; 71^{o}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

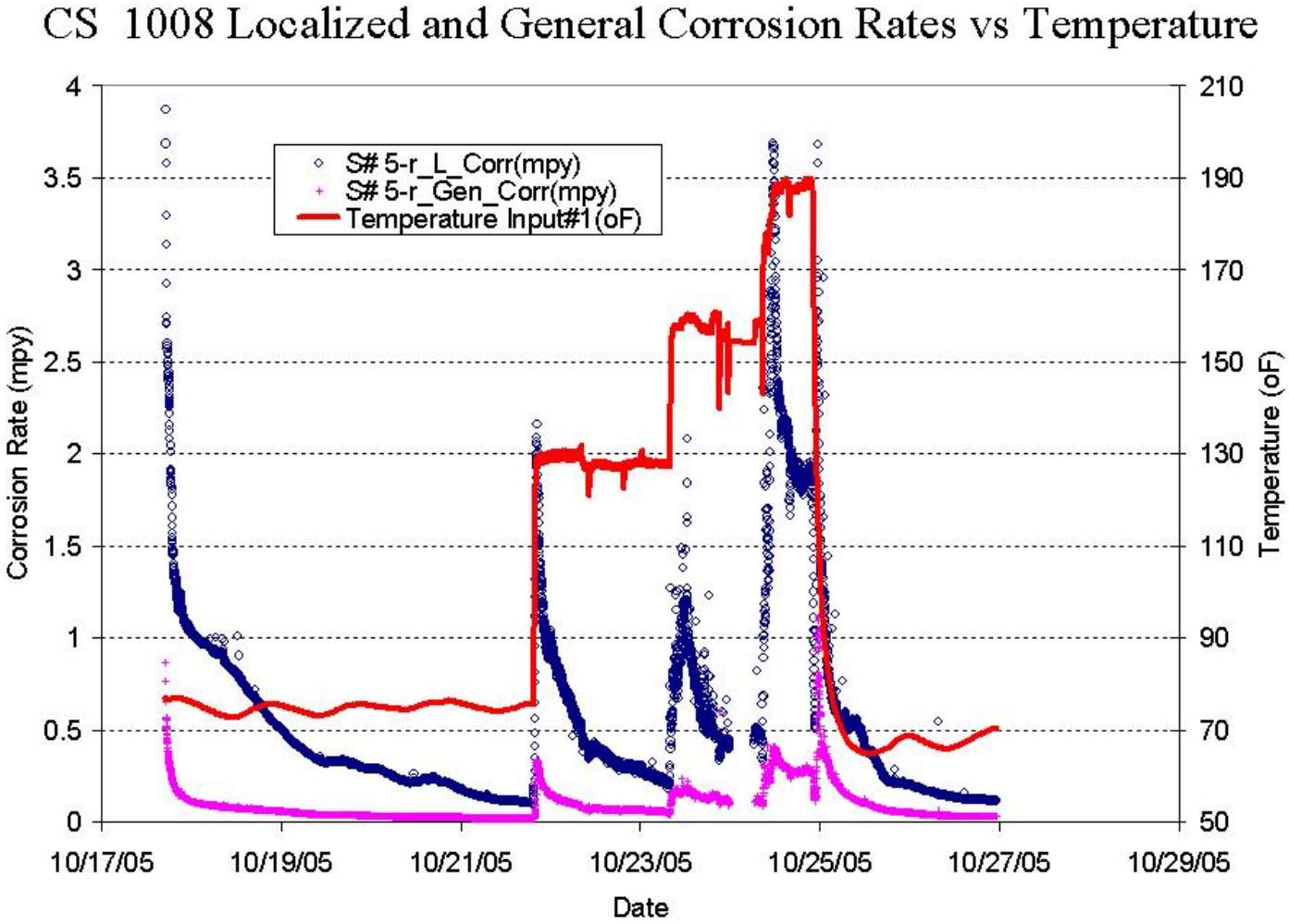
Unprotected Metals in Sea Salt

- High TDS (0.5 N sea salt) impact on CS, Al, Zn and SS metals @ 77^{o} F (room temperature).
- Localized corrosion measured at **40 MPY** for mild steel.
- Higher temperatures increase corrosion rates.
- Uninhibited seawater corrosion for steel, zinc, aluminum is 200-400X silica inhibited rates.

Uninhibited Sea Salt Study (High TDS)

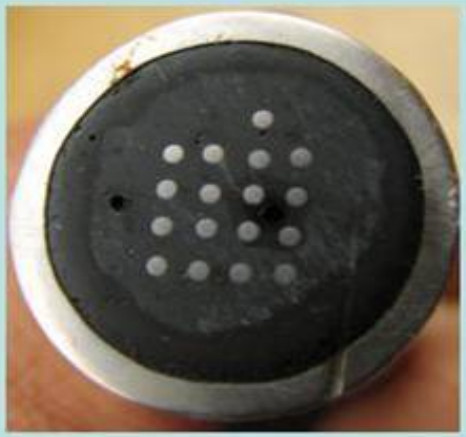


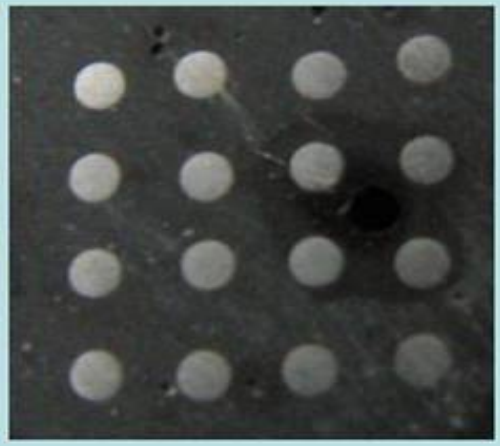
Silica Inhibited Study / High TDS



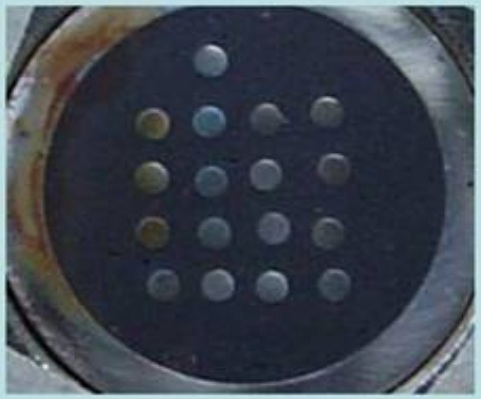
Protected by patents, US 6,929,749;
US 6,949,193; US 6,998,092

Post-Test Probes – Steel Localized Corrosion at 40 mpy in Unprotected Brine vs. < 0.2 mpy in Silica Inhibited Brine





Carbon steel, one week in high-silica brine solution (pH=10) at up to 190 °F



Three weeks in seawater at room temperature

Carbon steel

316L Probe

Corrosion Inhibition Results at High Temperature and 50,000 TDS

Metals	Inhibitor / Solution	Temp (° F)	Temp (° C)	General (mpy)	Max Loc (mpy)
CS 1008	Sea Salt	77	25	***	40.0
CS 1008	Silica	77	25	0.02	0.1
CS 1008	Silica	130	55	0.1	0.2
CS 1008	Silica	160	71	0.2	0.4
CS 1008	Silica	190	88	0.2	1.9
SS 316 L	Sea Salt	77	25	***	0.04
SS 316 L	Silica	77	25	< 0.0015	< 0.005
SS 316 L	Silica	130	55	< 0.01	< 0.01
SS 316 L	Silica	160	71	< 0.01	< 0.01
SS 316 L	Silica	190	88	< 0.01	0.013
AL 1100	Sea Salt	77	25	***	20.0
AL 1100	Silica	77	25	< 0.05	< 0.1
AL 1100	Silica	130	55	0.002	0.009
AL 1100	Silica	160	71	< 0.05	0.2
AL 1100	Silica	190	88	< 0.060	0.37
Zinc	Sea Salt	77	25	8.0	80.0
Zinc	Silica	77	25	< 0.05	< 0.01
Zinc	Silica	130	55	< 0.2	0.4
Zinc	Silica	160	71	***	2.0
CU 110	Sea Salt	77	25	***	0.4
CU 110	Silica	77	25	< 0.05	< 0.2
CU 110	Silica	130	55	< 1.0	3.0
CU 110	Silica	160	71	***	4.0

CSI Results with ZLD

EC West Tower ZLD Chemistry

EC West Tower - Concentration of Chemistry (COC) Ratios				
SAMPLE / TESTS		Tower	Makeup	COC
TDS, mg/L		44,000	250	176
pH		9.90	7.58	
Copper, mg/L Cu		ND	ND	
Zinc, mg/L		ND	ND	
Silica, mg/L SiO2		474	27.6	17
Calcium, mg/L CaCO3		14.5	< 0.1	
Magnesium, mg/L CaCO3		3.3	< 0.1	
Iron, mg/L Fe		ND	ND	
Aluminum, mg/L Al		ND	ND	
Sulphate, mg/L SO4		3375	19	178
Chloride, mg/L		954	3.8	251
Tot. Alkalinity, mg/L CaCO3		21,160	140	151
ND = Not Detected; COC = Concentration of Makeup Chemistry				

CSI - EC WEST Tower – 12 months Galvanized Tube Bundle / No White Rust (44,000 TDS / 176 COC)

CSI - EC WEST Tower
Galvanized Coated Steel Coupon
60 Day Exposure

CSI - EC WEST Tower - Mild Steel Coupons

60 Day Exposure VS Non-exposed

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

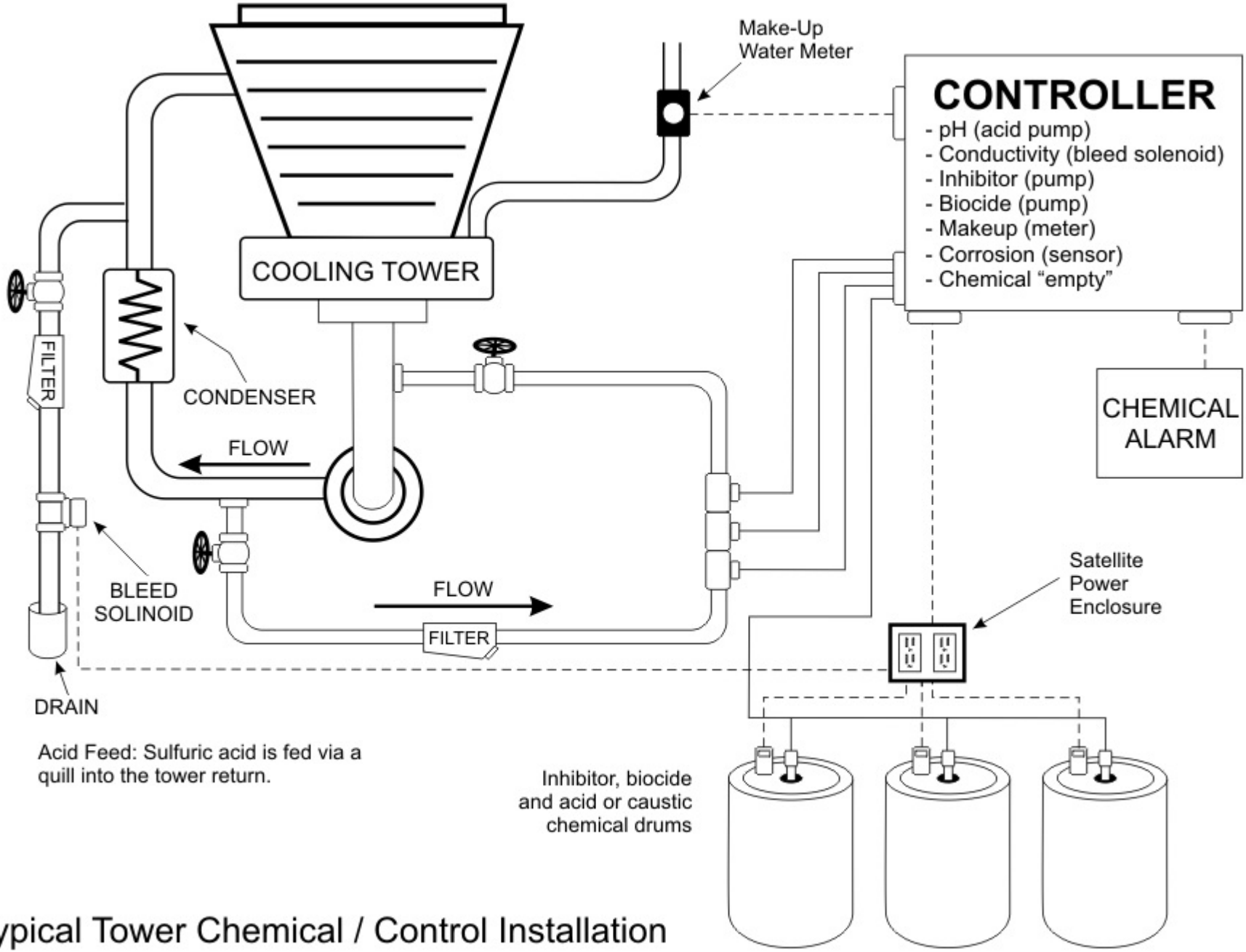
EC 10 Tower ZLD Chemistry

EC 10 Tower - Concentration of Chemistry (COC) Ratios			
SAMPLE / TESTS	Tower	Makeup	COC
TDS, mg/L	125,000	250	500
pH	10.05	7.58	
Copper, mg/L Cu	ND	ND	
Zinc, mg/L	ND	ND	
Silica, mg/L SiO2	800	27.6	29
Calcium, mg/L CaCO3	29	< 0.1	
Magnesium, mg/L CaCO3	6.6	< 0.1	
Iron, mg/L Fe	ND	ND	
Aluminum, mg/L Al	ND	ND	
Sulphate, mg/L SO4	9150	19	481
Chloride, mg/L	1910	3.8	502
Tot. Alkalinity, mg/L CaCO3	67,000	140	478
ND = Not Detected; COC = Concentration of Makeup Chemistry			

CSI - EC #10 Tower – 10 months Galvanized Tube Bundle / No White Rust (125,000 TDS, 500 COC, 105° F / 77° F)

CSI Effluent Control Impact

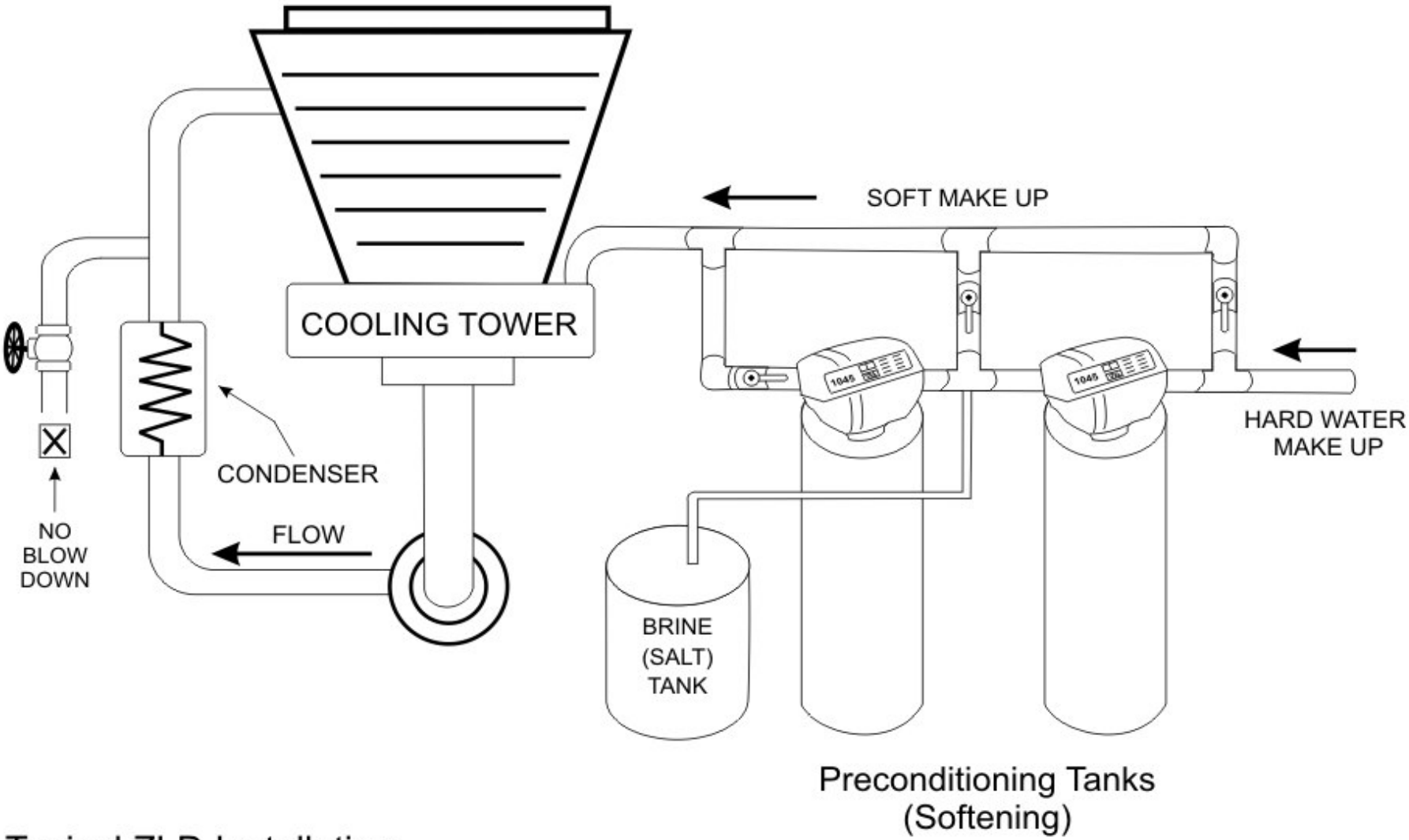
- Averted cost of discharge piping system
- 98% reduction in waste haul volume
- 30% reduction in tower makeup water
- No chemical or biocide used / discharged
- Eliminated chemical storage / handling
- Design heat transfer efficiency maintained
- Galvanized metals protected at high TDS



Typical Tower Chemical / Control Installation

Typical Chemical Installation

- Must feed acid and/or inhibitors to reduce water wastage to 10-20% range.
- Requires control systems for conductivity (blow down), pH / acid, inhibitor & biocide.
- Significantly higher corrosion rates, and increased risk for scaling with failure of even one of the multiple control systems.
- Chemical handling and storage risks.



Typical ZLD Installation

Typical ZLD Installation

- Tower makeup water passes through polisher.
- Scale risk eliminated by removal of hardness.
- Blow down is reduced to ZLD, or < 5% range.
- No chemical feed or control systems required.
- Corrosion almost zero for all metals.
- Environmentally friendly / no toxic chemicals.
- Just maintain salt in tank / low usage design.

Low Regenerant Use Pre-conditioning Systems

- Design permits **4#** /CF salt regeneration
- 50% salt use reduction
- 70% reduction in regeneration waste water
- Dual continuous treated water / polished quality / automated regeneration
- Cost less than chemical program feed & control systems

“Green” Inhibitor Chemistry

- System chemistry derived from concentration of (soft) makeup water ions and silica
- Natural, non-toxic source water chemistry
- Organic corrosion and scale inhibitors are not required or discharged
- Limited or no microbiological control agents
- Blow down is not required

Other Benefits of Silica / ZLD

- Permits use of reclaimed waste water, RO reject, or brackish water sources
- Protect metals from high chlorides, sulfates, alkalinity, ammonia, organics
- Protects galvanized and aluminum metals
- Expands metal selection / cost options

Application Experience

- Four years of application and evaluation
- Customers include Industrial, Food, and Commercial/Institutional systems.
- Tower system metals include mild steel, copper, galvanized, stainless, aluminum.
- Cooling towers include Marley, BAC, Evapco, Delta.

ZLD / Silica Program Summary

- No scale with “ZLD” operation
- Almost zero corrosion at extreme high TDS
- Silica also excellent at high temperatures
- Al, Zn, Cu can be used at high pH (10)
- Mitigates biological and pathogen growth
- Potential reclaim / “grey” water reuse
- “Green” chemistry and reduced water use

... please help sustain our water sources and environment!

Questions?