

NACE 2007 / TEG 095X
Inhibitors High-Temperature

Evaporative Cooling Systems
Perspective

High Temperature Limitations for Metals used in Cooling Water

- Define “high” as 130 to 190° F
- Significant proportion of applications
- Economics of metal options important

Metal Applications

- Principal metals used in heat transfer and transport of water are MS, Cu, Al, SS
- MS, Cu and Al used below 130° F
- MS, Cu and AL used over 130° F for closed systems with low O₂ / high inhibitor
- MS and SS mostly used above 130° F
- Economics and heat transfer driven
- MS and Cu serve majority of applications

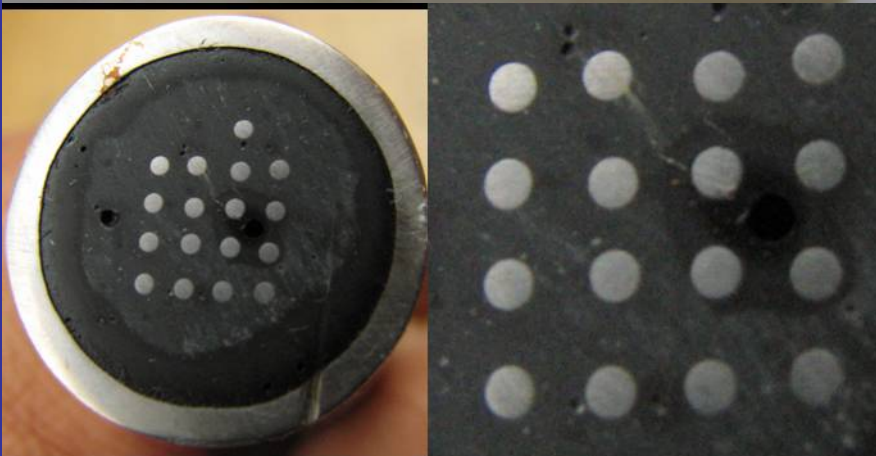
Economics of System Metals

- Practical metals of construction are mild steel, copper, and aluminum
- Malleable / workable for exchange design
- Best heat transfer properties
- Affordable for broad range of applications
- Corrosion limits effectiveness as bulk water increases from 130 to 190° F
- Challenge – provide better inhibitors

Example of High Temperature Studies with Inhibitor

Independent Laboratory
Electrochemical Corrosion Study
of Selected Metals

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
 - pH 10.0
- 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

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	-	60
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
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
Zn	Sea Salt	77	25	8	80
Zn	Silica	77	25	< 0.05	< 0.01
Zn	Silica	130	55	< 0.2	0.4
Zn	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

High Temperature / High TDS Inhibitor Study Conclusions

- MS is suitable for bulk water operation at 130° to 190° F with silica inhibitor
- Cu resists high TDS corrosion below 130°
- Cu prone to pitting corrosion above 130° F (also vulnerable to NH_3 ion)
- Al & Zn normally attacked at high pH (10), well protected by silica at high TDS
- Al could replace Cu above 130° F for heat transfer if structural properties adequate