GE Power & Water
Water & Process Technologies

Innovative water treatment solutions for seawater open evaporative systems

1st NACE Jubail Industrial Forum

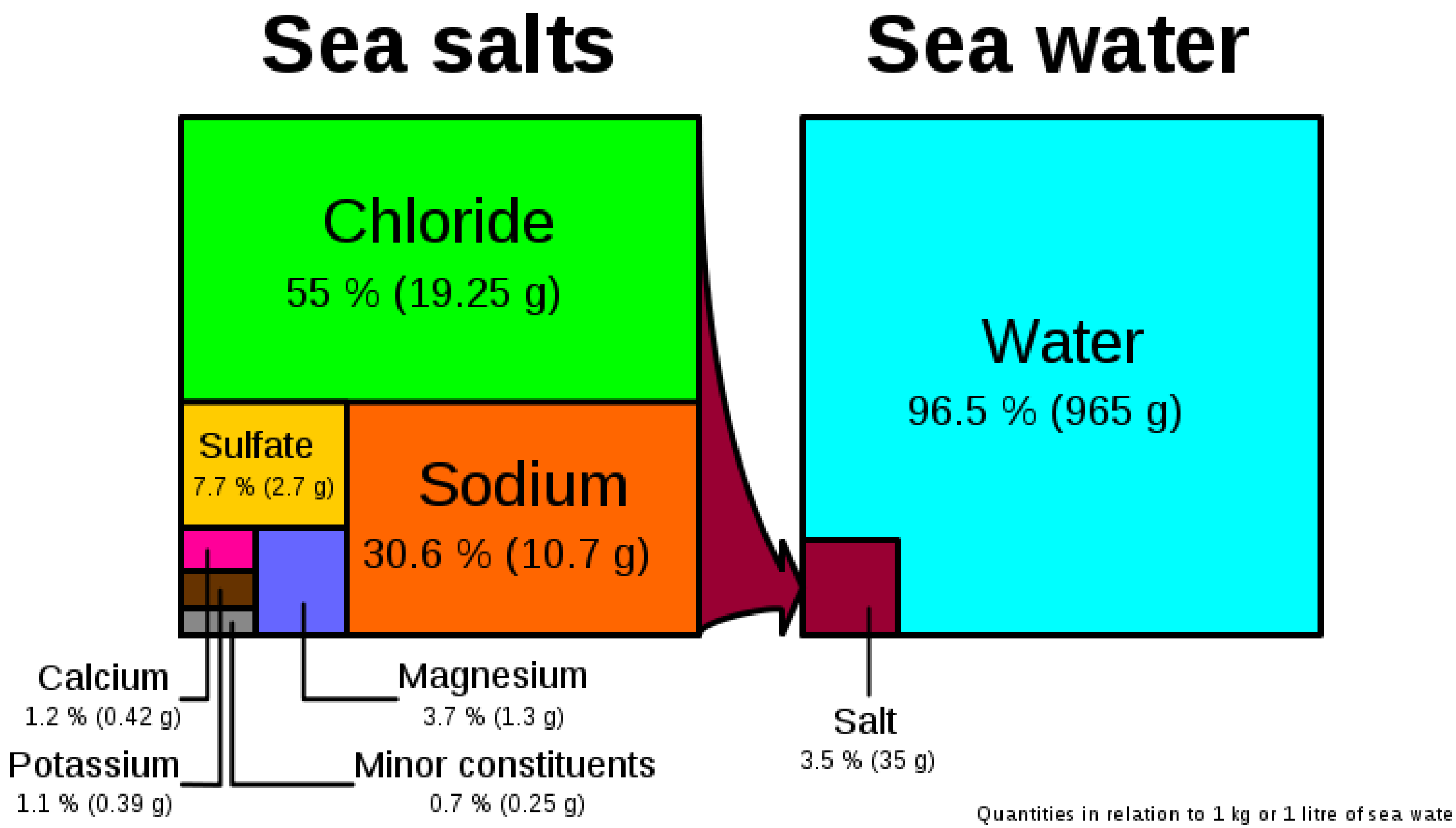
17 – 19 Oct, 2011

Shereif Alsayed

GE imagination at work

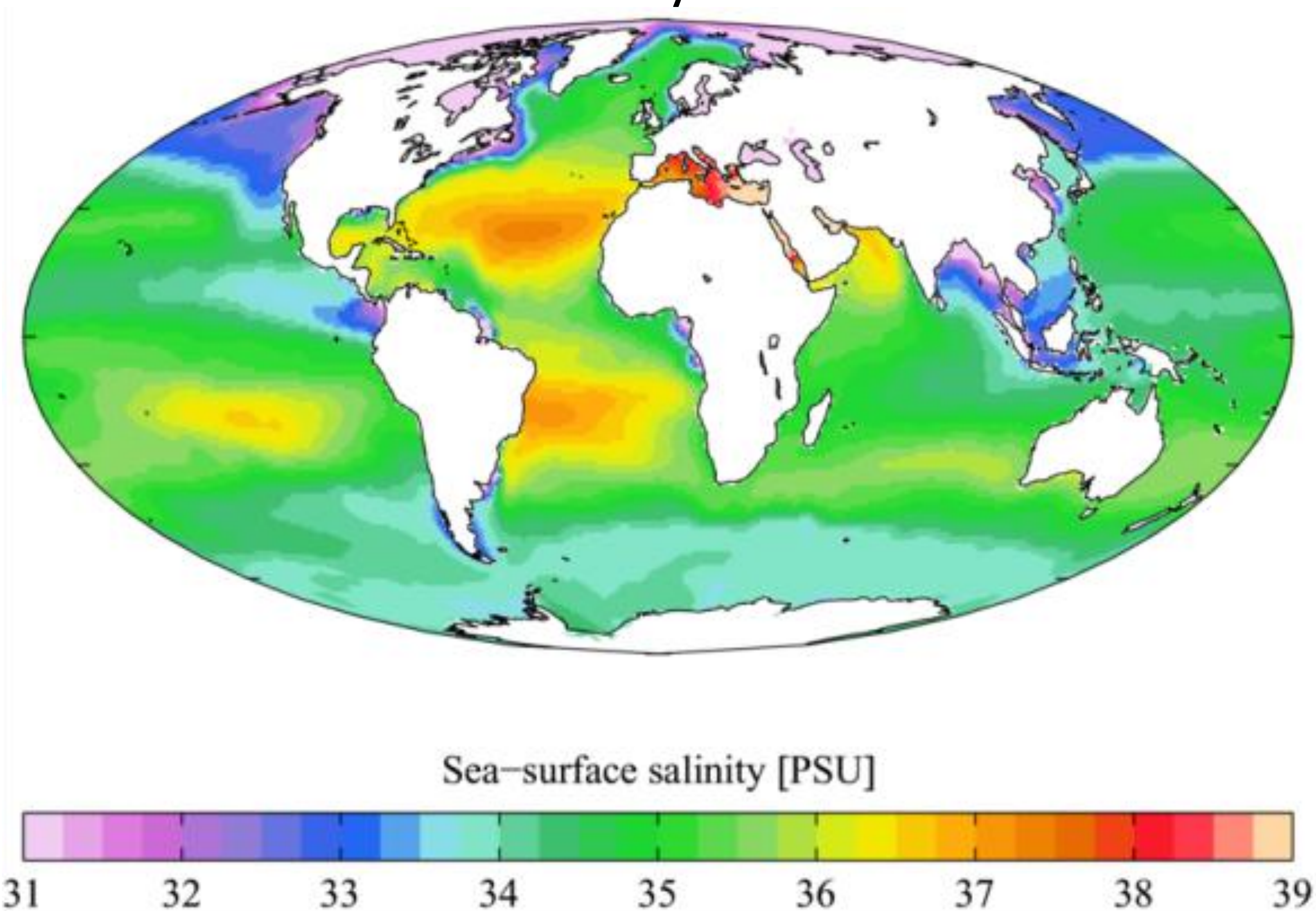
Seawater Properties

Seawater Salinity Composition



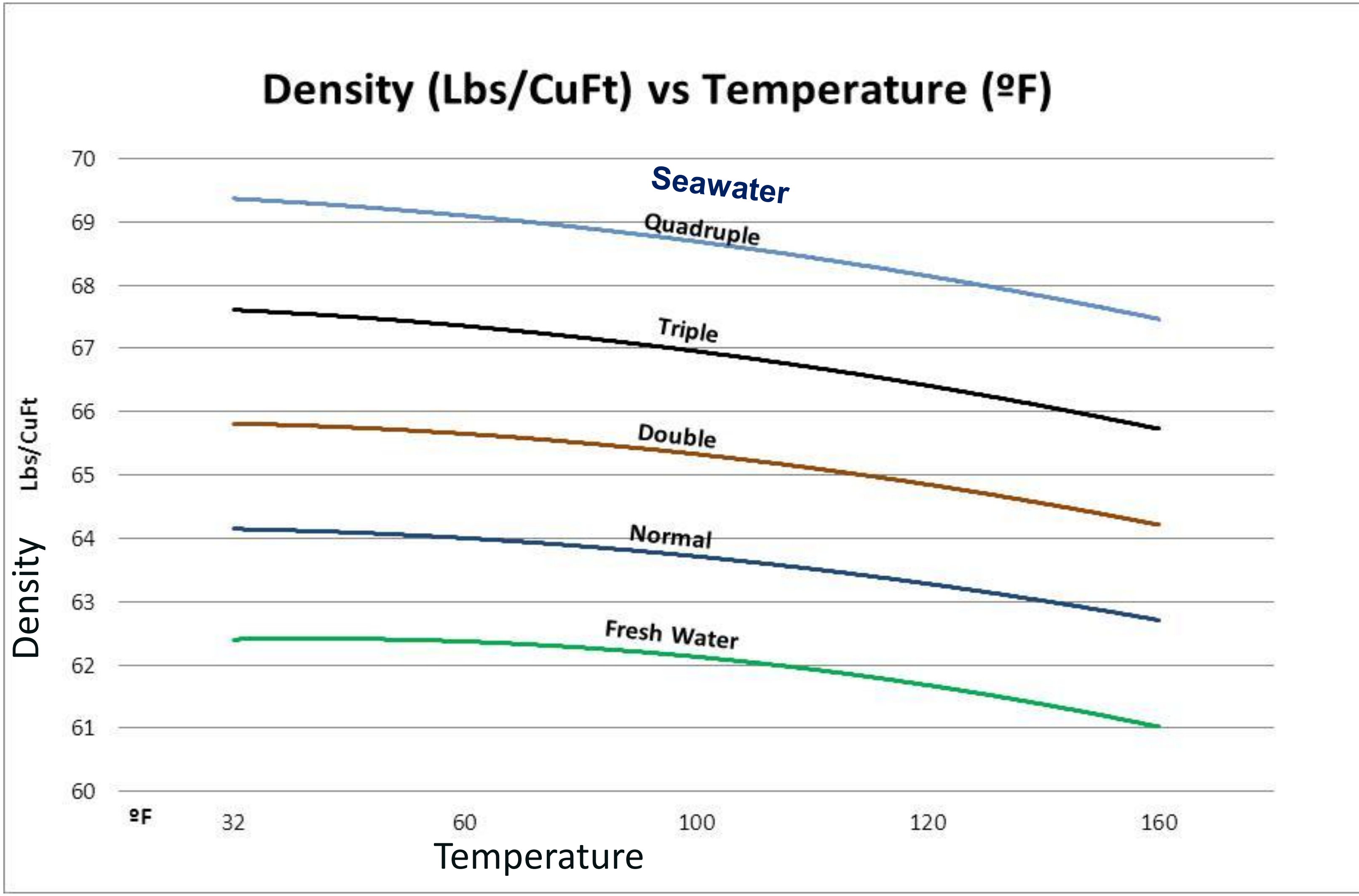
Seawater Properties

Seawater Salinity Distribution

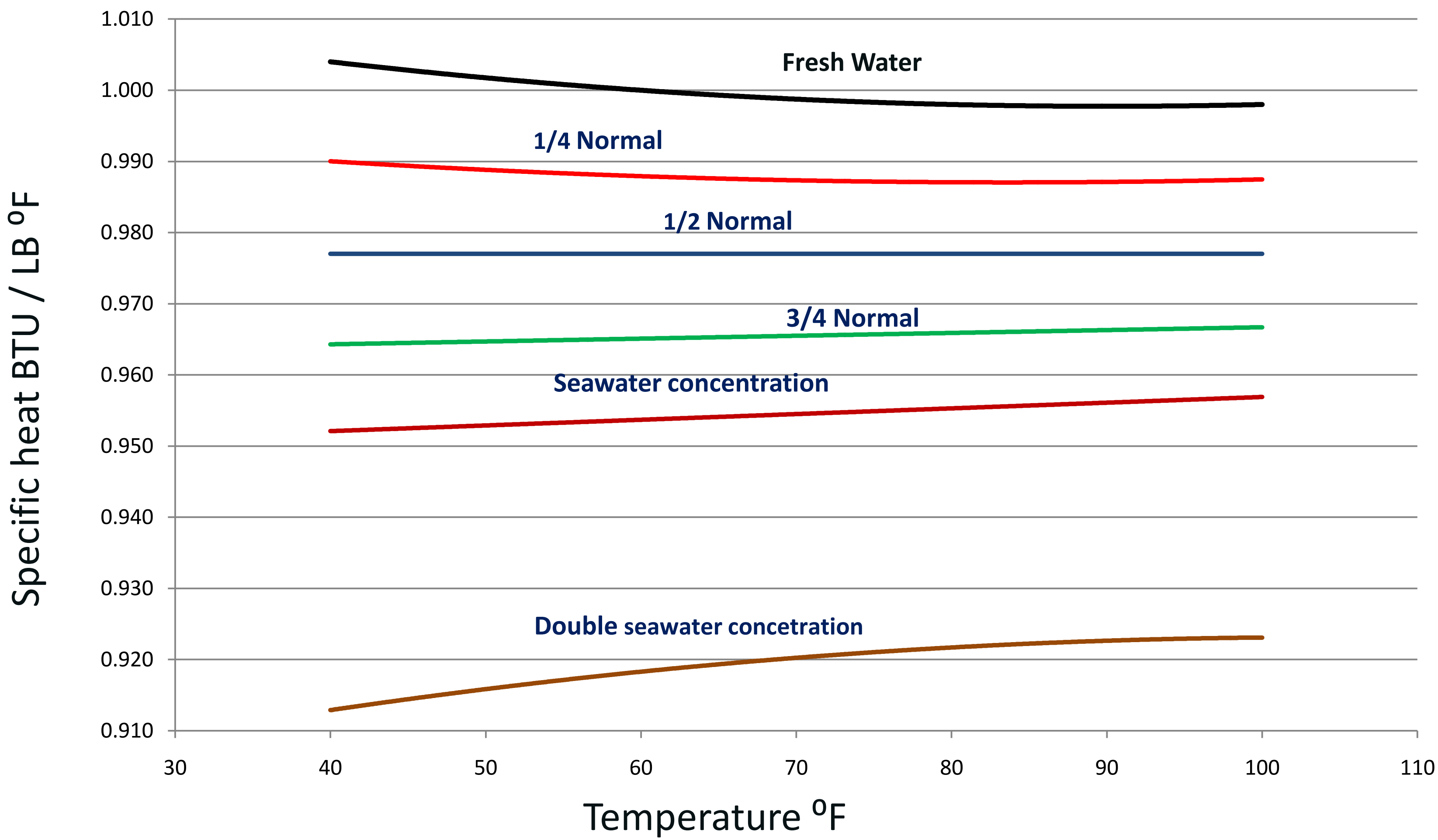


Source: World Ocean Atlas 2005. Retrieved 17 October 2010

Seawater Properties



Seawater Properties



Factors affecting physical properties

PARAMETER	**Density**	**Specific Heat**
• Conductivity	↑	↓
• Temp	↓	↑
• Depth	↑	↓

- Desalination plants reject.
- Vicinity of other plants.

Seawater Properties

- Effect of lower specific heat

Energy required = heat rejected= Q

Q = specific heat x mass x DT

Q(brackish water) = specific heat x mass x DT

Q(Seawater) = specific heat x mass x DT

Q brackish water / Q seawater = > 1

$\Rightarrow$ Brackish cooling system is less efficient

Q: Cal ,C_p: Cal/g °C, Mass:g, DT: °C
Q: BTU, C_p: Btu/ Lb °F, Mass: Lb, DT: °F

Seawater Properties

- Effect of higher density

Energy required = heat rejected= Q

Q = specific heat x mass x DT

Q(brackish water) = specific heat x mass x DT

Q(Seawater) = specific heat x mass x DT

Q brackish water / Q seawater = < 1

Seawater cooling system is less efficient

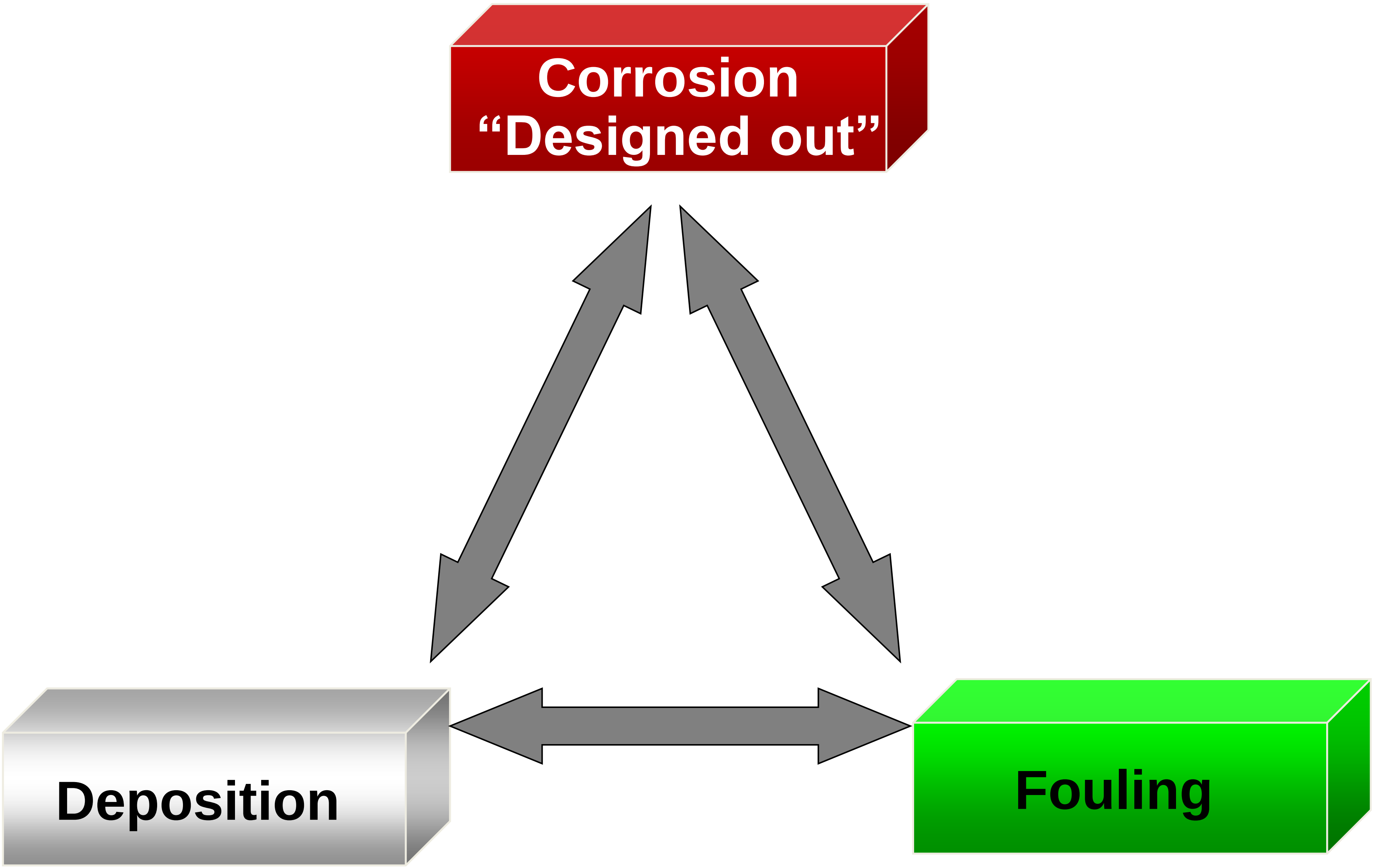
Q: Cal ,C_p: Cal/g °C, Mass:g, DT: °C
Q: BTU, C_p: Btu/ Lb °F, Mass: Lb, DT: °F

Seawater Properties

Loss in energy can be compensated by:

- ❑ Increased tower size.
- ❑ Adjusting fan horsepower.
- ❑ Increased circulation rate.

Treatment Concerns


Corrosion
“Designed out”
Deposition
Fouling

Scale Formation

Scale Formation

Calcium Carbonate

Scale potential depends on:

- ❑ Calcium
- ❑ pH control
- ❑ Alkalinity
- ❑ Temperature
- ❑ Ionic strengths

Scale Formation

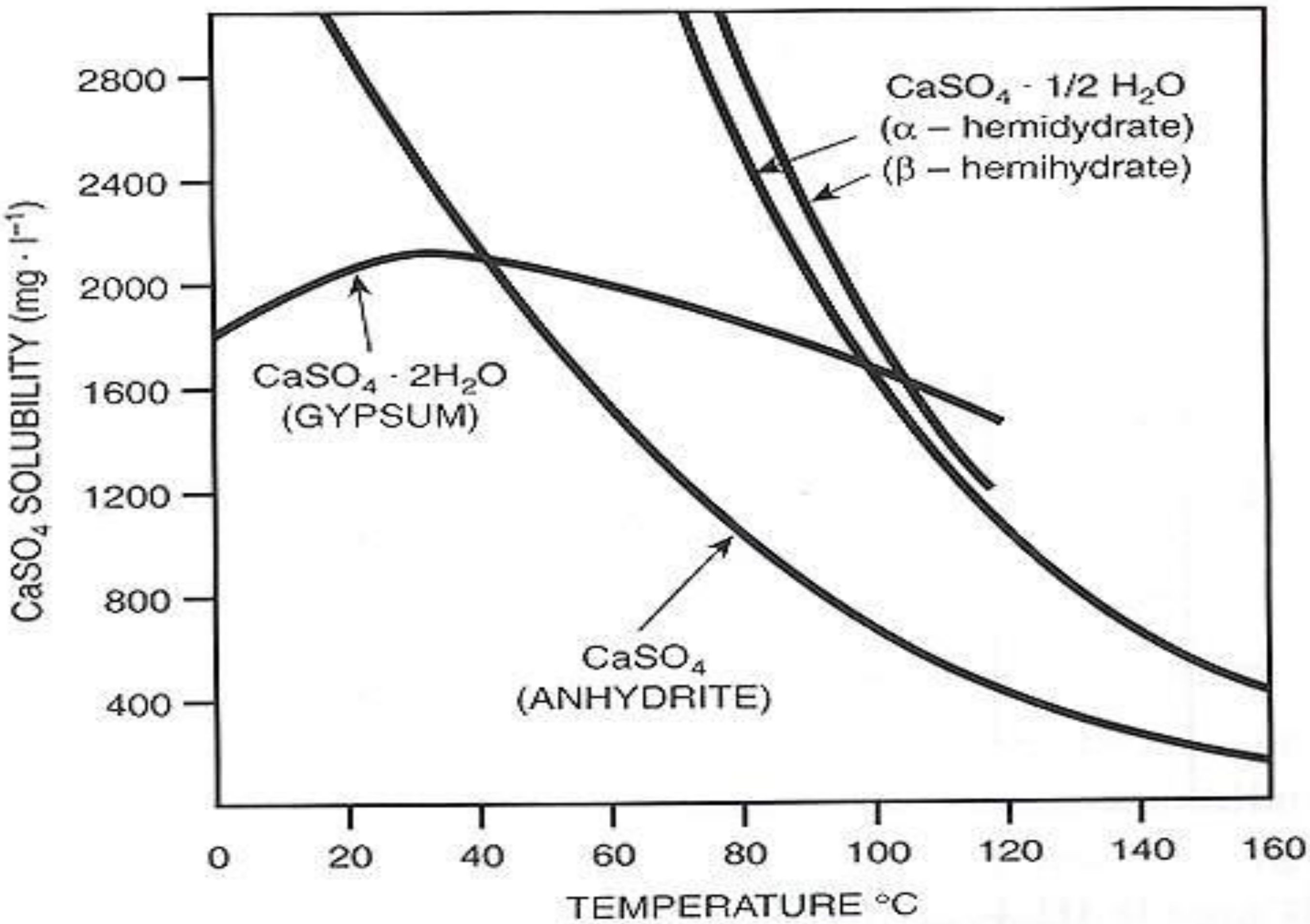
Calcium Sulphate

Scale potential depends on:

- ❑ Calcium
- ❑ Sulphate
- ❑ Ionic strength

Scale Formation

$CaSO_4$ Solubility



Scale Formation

Silicate

Factors affecting deposition

- Magnesium
- Silicate
- pH

New Technology

Treatment practices overview

- Typical cycles (1.2 – 1.3).
- No pH control or adjustment.
- Continuous chlorination.
- Material of construction.
  - Sacrificial anode for yellow metallurgy alloys.

Sea Water and Open Evaporative Cooling

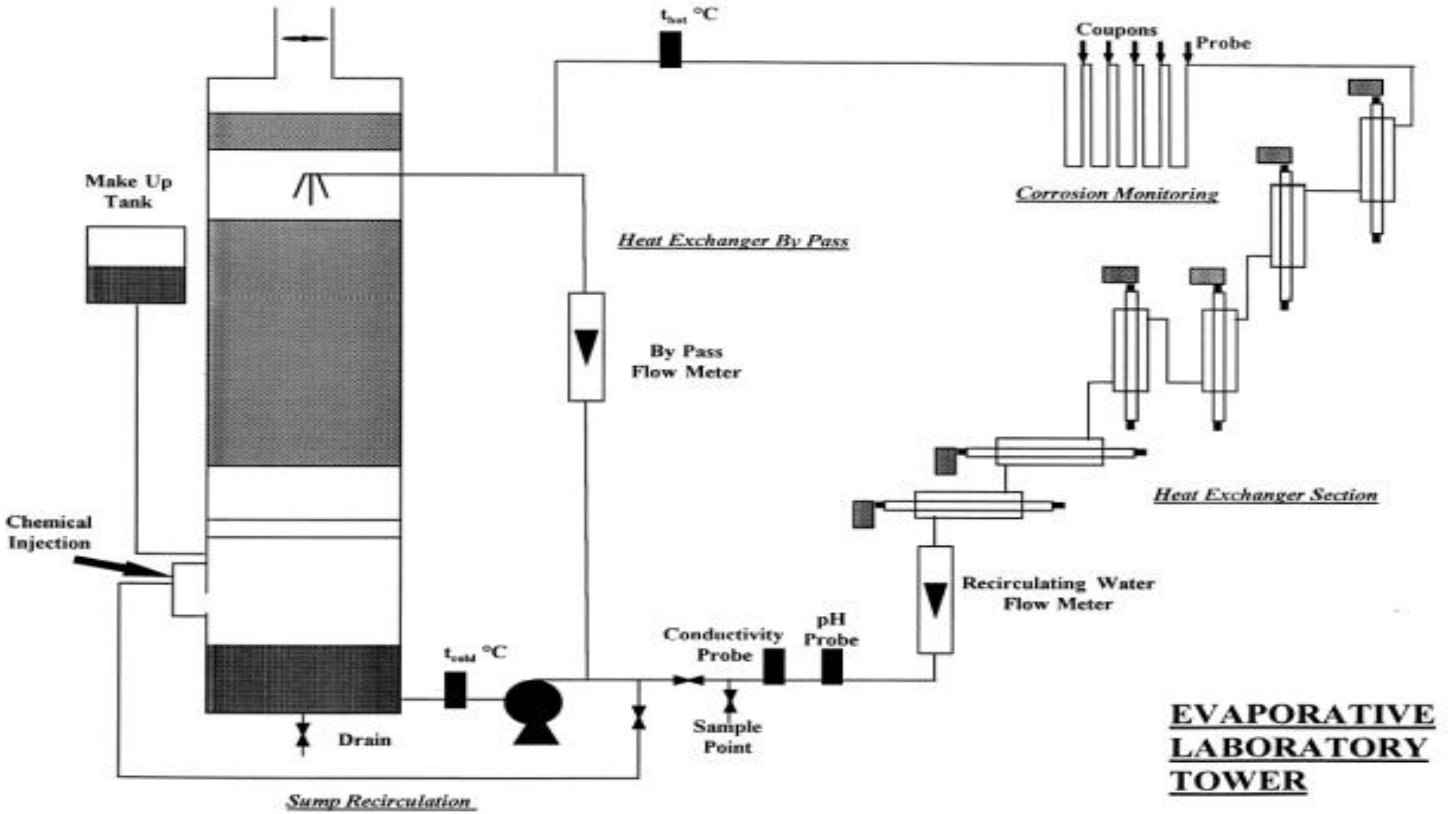
GE technology reached > 80,000 ppm, free pH

SALT WATER

By John A. Nelson • The Marley Cooling [illegible] • November 5, 1986

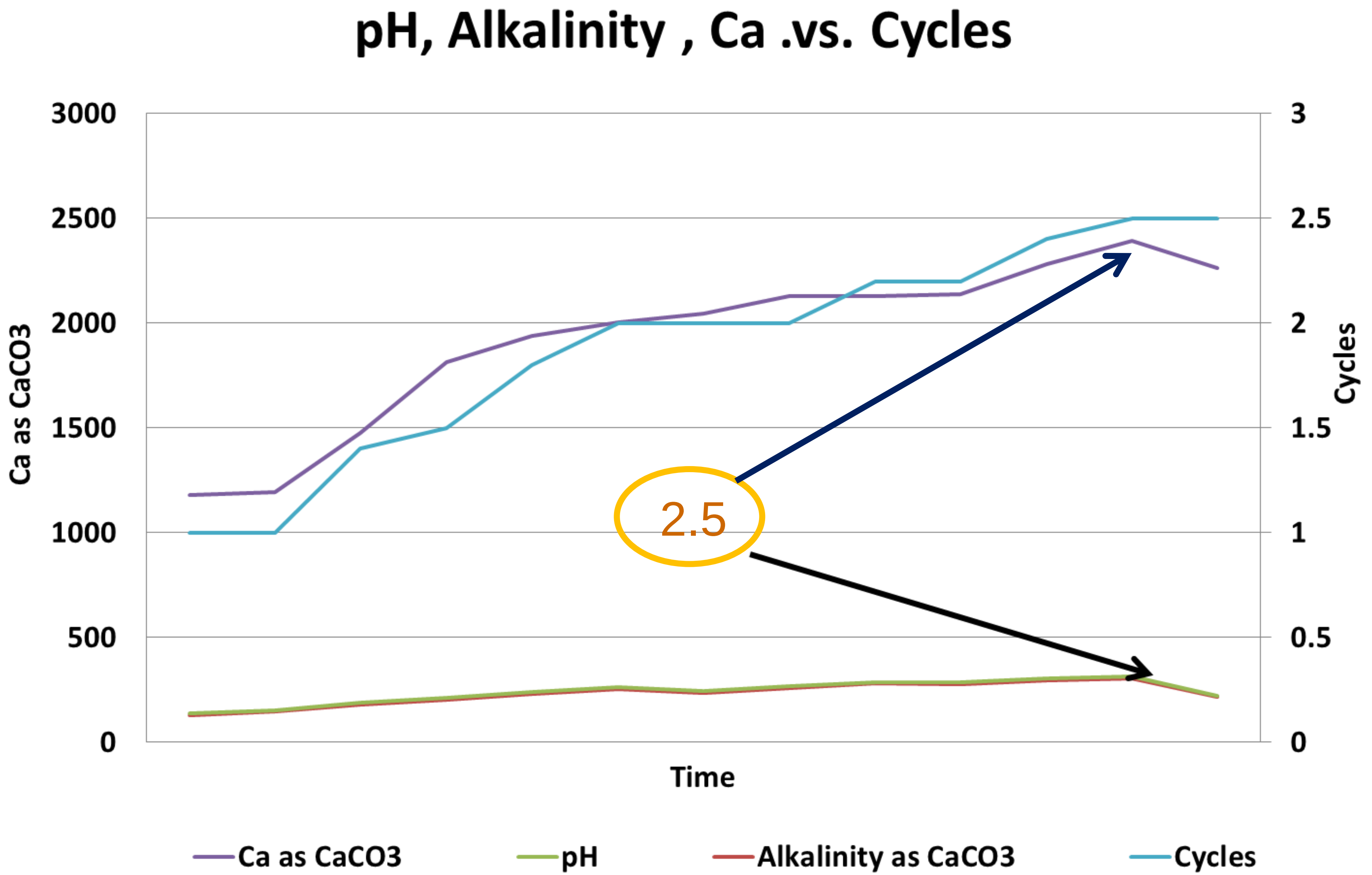
"Generally, sea wate[illegible]ntrated to approximately 55,000 ppm salinity with n[illegible]nt without serious scaling problems in the exchang[illegible]ncentrations are possible but pH control by acid addit[illegible] probably be required. Two of the major users of sea water [illegible]ing towers operate to 55,000 ppm salinity as the upper limit and this procedure has been satisfactory."

Evaluation of Inhibitors



Operating Conditions

- Coupons: Ti , 70/30 Cu/Ni,
- CRM Probe: 70/30 Cu/Ni
- Heat Exchanger Tubes: Ti, 70/30 Cu/Ni
- Water Temperature: 40 °C
- Estimated Skin Temperature: 52 °C
- Water Velocity: 1.5 m/s



pH, Alkalinity , Ca .vs. Cycles
3000
2500
2000
1500
1000
500
0
Ca as CaCO3
3
2.5
2
1.5
1
0.5
0
Cycles
2.5
Time
Ca as CaCO3
pH
Alkalinity as CaCO3
Cycles

Corrosion Coupons

CRM probe corrosion Cu/ Ni 70-30 : 0.9 mpy

Heat exchanger tubes

Technology Guide

- ❑ Stiff & Davis Max 1.50 @ 52ºC (skin)
- ❑ Up to theoretical LSI of 2.5 @ 52ºC.
- ❑ Max 2.4 cycles (depending on chemistry).
- ❑ Free pH, pH of 8.4.

% Make-up Reduction by Cycles Increase

1.3

Proposed Scenario	Actual situation												
	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3
1.1													
1.2	45.5 %												
1.3	60.6 %	27.8%											
1.4	68.2 %	41.7%	19.2%										
1.5	72.7 %	50,0%	30.8%	14.3%									
1.6	75.8 %	55.6%	38.5%	23.8%	11.1%								
1.7	77.9 %	59.5%	44.0%	30.6 %	19.0 %	8.9%							
1.8	79.5 %	62.5%	48.1%	35.7 %	25.0 %	15.6%	7.4%						
1.9	80.8 %	64.8%	51.3%	39.7 %	29.6%	20.8%	13.1%	6.2%					
2.0	81.8 %	66.7%	53.8%	42.9 %	33.3%	25.0%	17.6%	11.1%	5.3%				
2.1	82.6 %	68.2%	55.9%	45.5 %	36.4%	28.4%	21.4%	15.2 %	9.6%	4.5%			
2.2	83.3 %	69.4%	57.7%	47.6 %	38.9%	31.3%	17.2%	18.5 %	13.2%	8.3%	4.0%		
2.3	83.9 %	70.5%	59.2%	49.5 %	41.0%	33.7%	27.1%	21.4%	16.2%	11.5%	7.3%	7.7%	

1.6

38.5 %

- ❑ 38.5 % saving in make up requirement.
- ❑ Reduced energy consumption (make up, blow down pumps)
- ❑ Forgiving program, higher tolerance for upsets and excursions.
- ❑ Compatible with halogenation practices.

Technology Features & Advantages