McIlvaine Hot Topic Hour

Power Plant Cooling Towers & Cooling Water Issues

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Agenda

- Impact Considerations for Cooling Tower Systems
  - Corrosion, Scale, Microbiological
  - Holding Time Index
  - Induction Time
- Best Available Technologies – Focus on Microbiological Control
  - Chlorine or Sodium Hypochlorite
  - Chlorine Dioxide
  - Mixed Oxidant
  - Bio-Dispersants
  - Stabilized Bromine

Impact Considerations for Cooling Tower Systems

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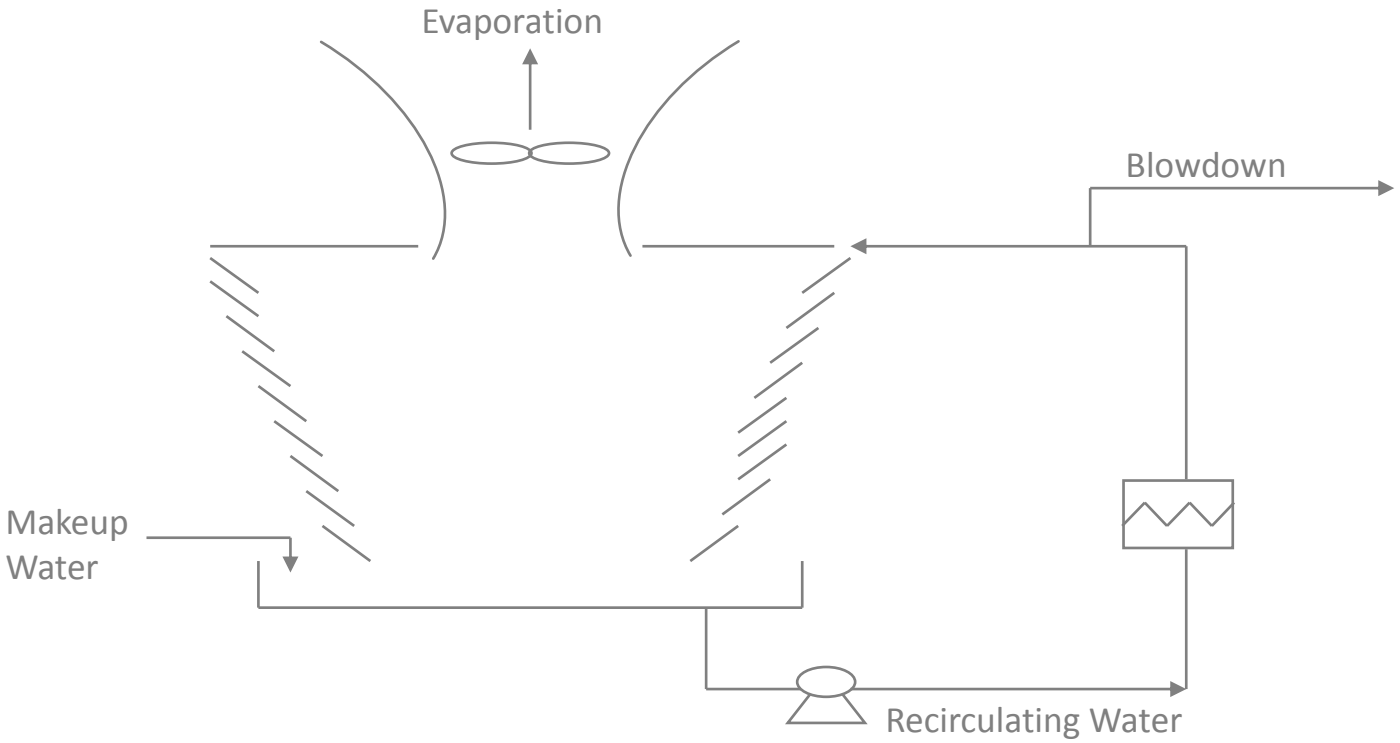
Cooling Towers

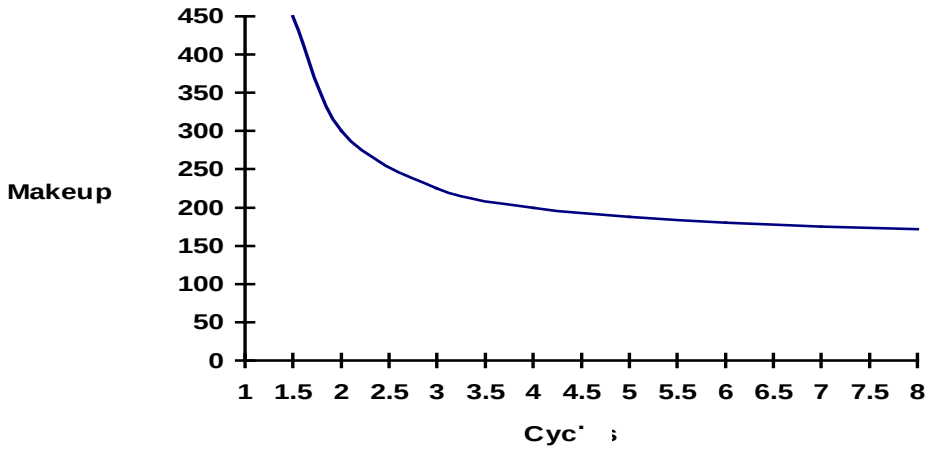
- Due to the evaporation and cycling factor of cooling towers, the water balance shifts when compared to once-through cooling



Water Balance

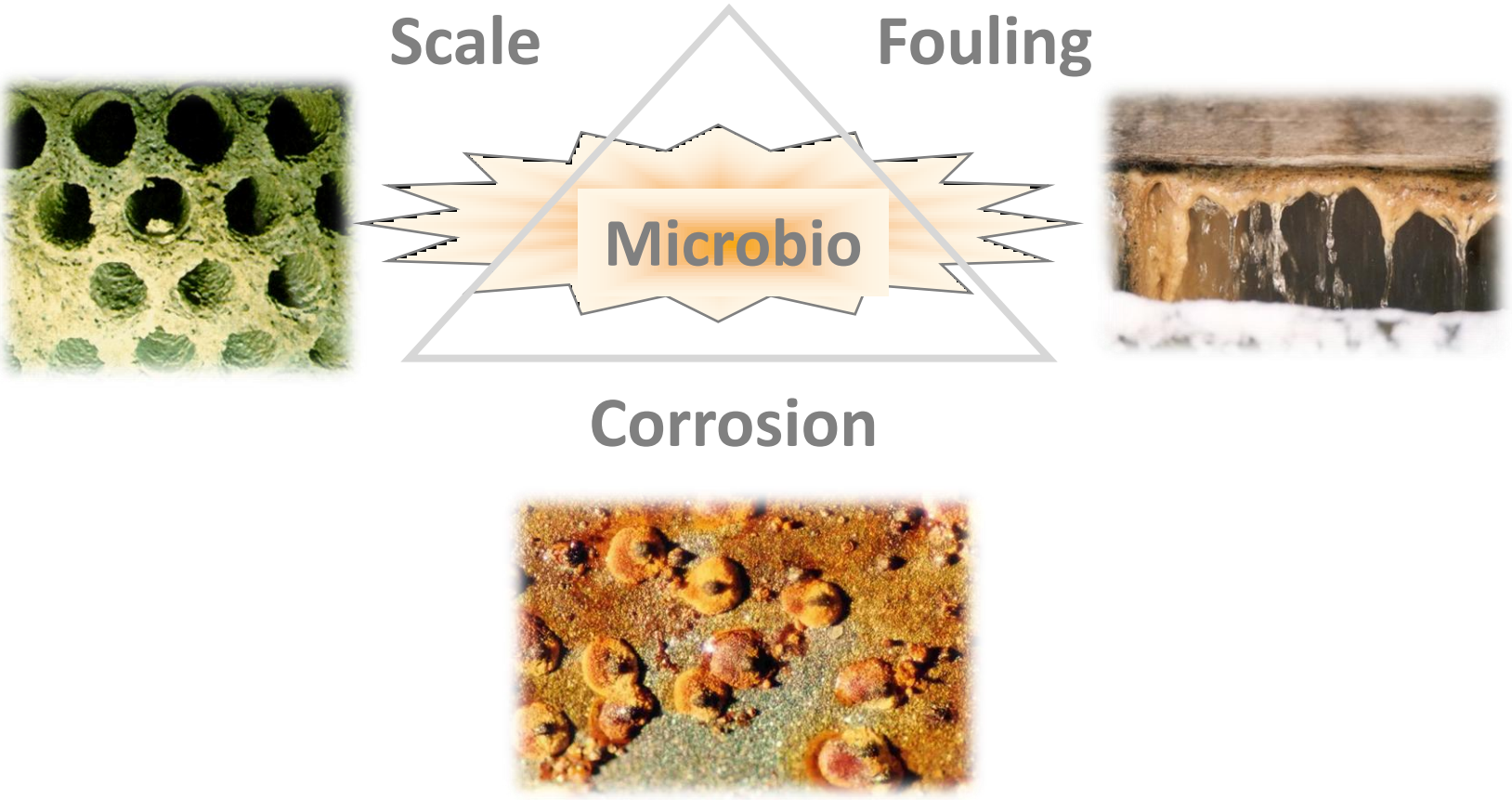
Recirculation Rate 100,000 gpm; $\Delta T = 15°$

Cycles	Evaporation (gpm)	Blowdown (gpm)	Makeup (gpm)
1.5	1,500	3,000	4,500
2	1,500	1,500	3,000
3	1,500	750	2,250
4	1,500	500	2,000
5	1,500	375	1,875
6	1,500	300	1,800
7	1,500	250	1,750
8	1,500	214	1,714

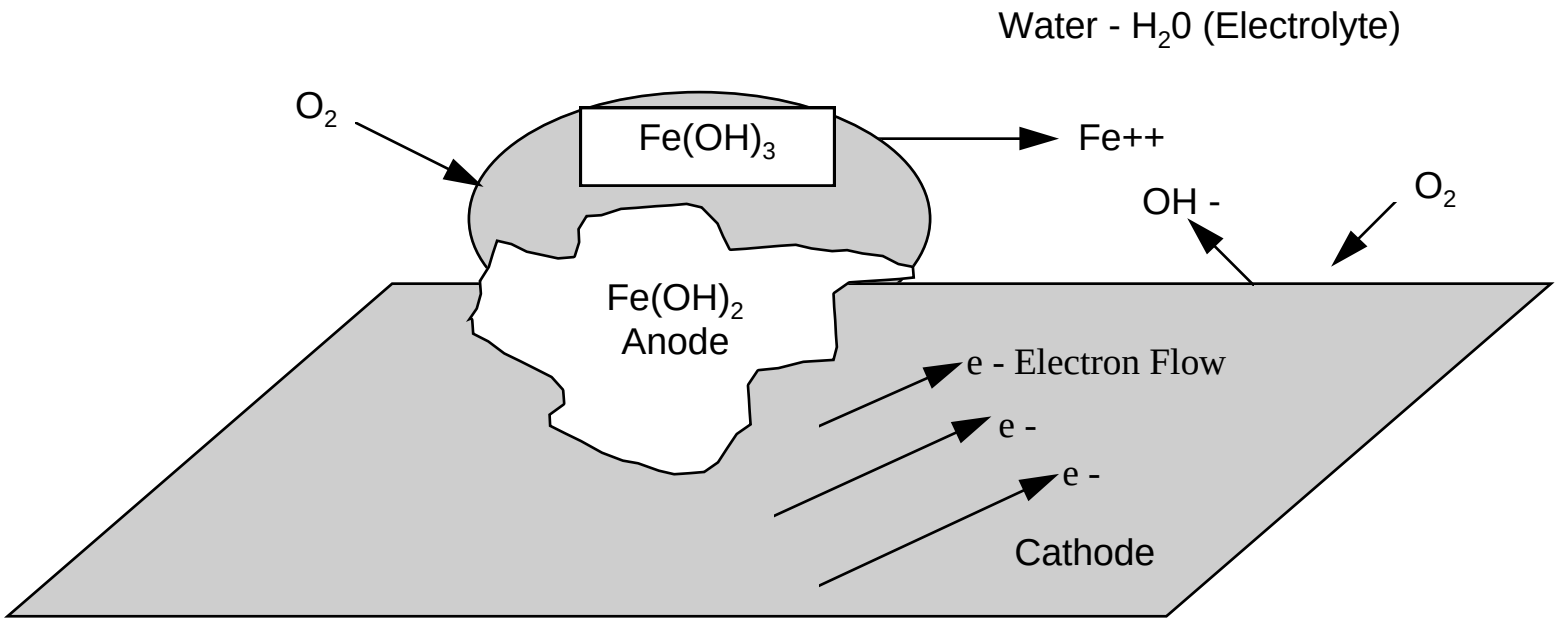


Challenges

- Cooling towers present challenges not experienced with once-through systems due to the “cycling” factor as a result of evaporation



Corrosion



Corrosion of Carbon Steel

Scale & Corrosion

Scale & Corrosion Rates

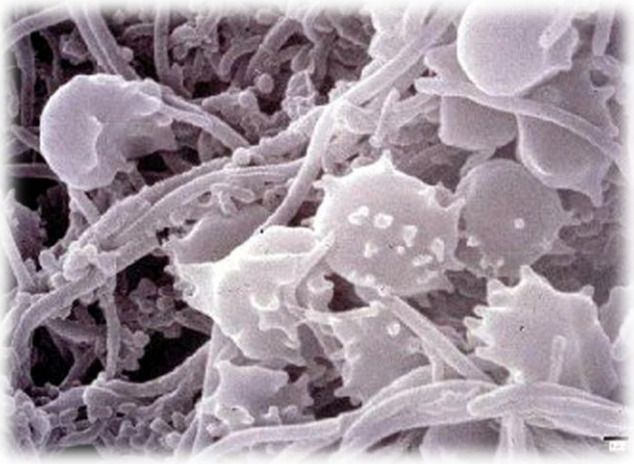
In general, for every 10°C in water temperature, chemical reaction rates double

As cycles rise, the contaminants in the makeup water increase proportional, not considering effects of scaling tendencies on bulk water concentrations, affecting corrosion control

		CT Makeup	Cooling Tower
Total Hardness	$CaCO_3$	168	672
Calcium Hardness	$CaCO_3$	120	480
Magnesium Hardness	$CaCO_3$	58	232
Phenolphthalein Alkalinity	$CaCO_3$		
Total Alkalinity	$CaCO_3$	104	416
Sulfate	SO_4	50	200
Chloride	Cl	75	300
Silica	SiO_2	8	32
Total Phosphate	PO_4	0.2	0.8
Iron	Fe	0.25	1.00
pH	S.U.	7.8	8.8
Conductivity	µS/cm	440	1,760

Scale

- Deposition and fouling involves both:
  - Inorganic contaminants
  - Organic contaminants

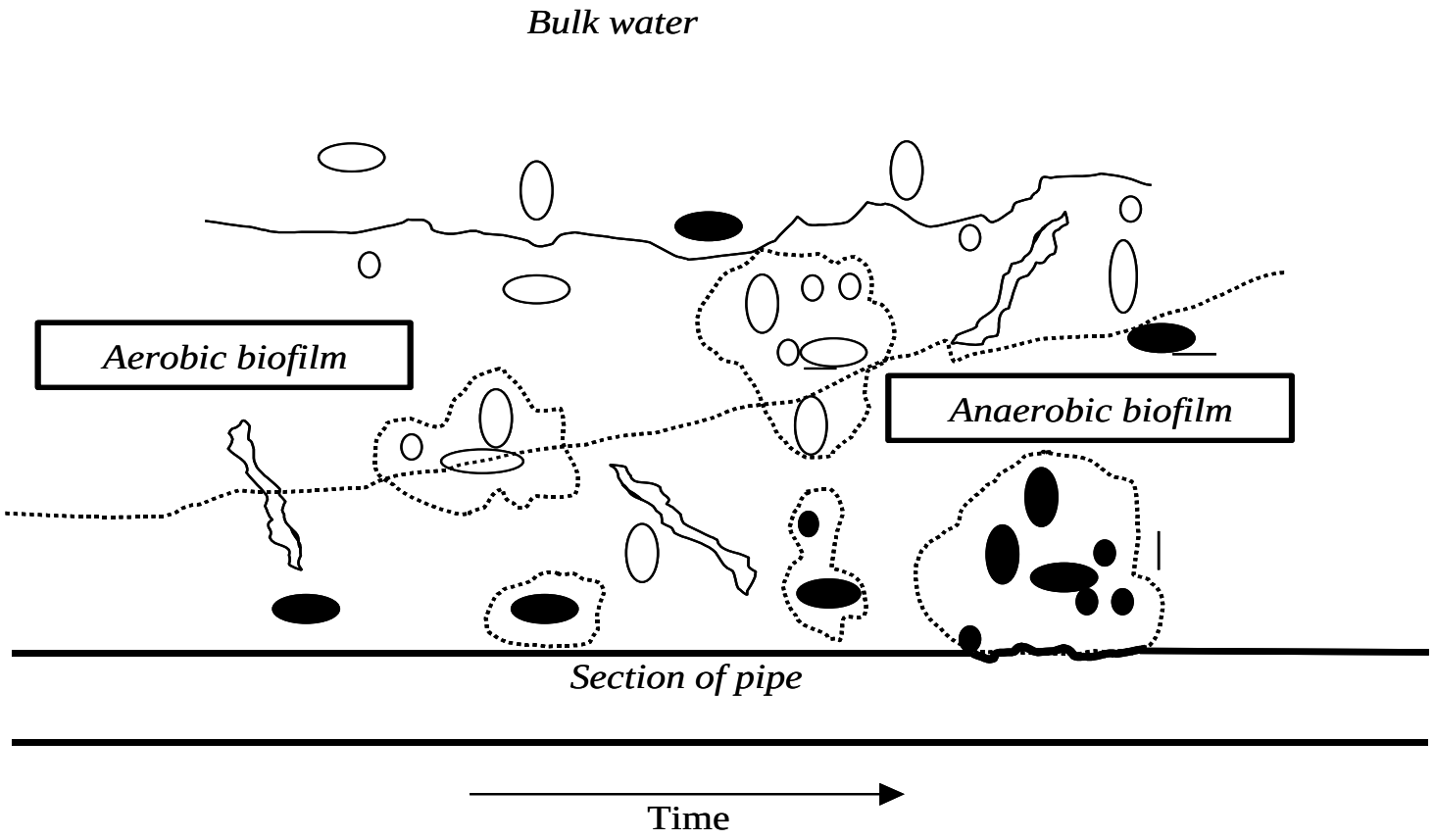


Microbiology in Cooling Water Systems

- MB organisms are introduced to cooling towers in many ways:
  - Airborne from soil, particulates, dust
  - Makeup water
  - Piping and existing biofilm
- Types of MB organisms are varied; slime formers lead to biofilm, and some such as sulfate reducing bacteria create corrosive environments, both leading to microbiologically influenced corrosion (MIC)
- Exist in ALL areas of a cooling system

Microbiology in Cooling Water Systems

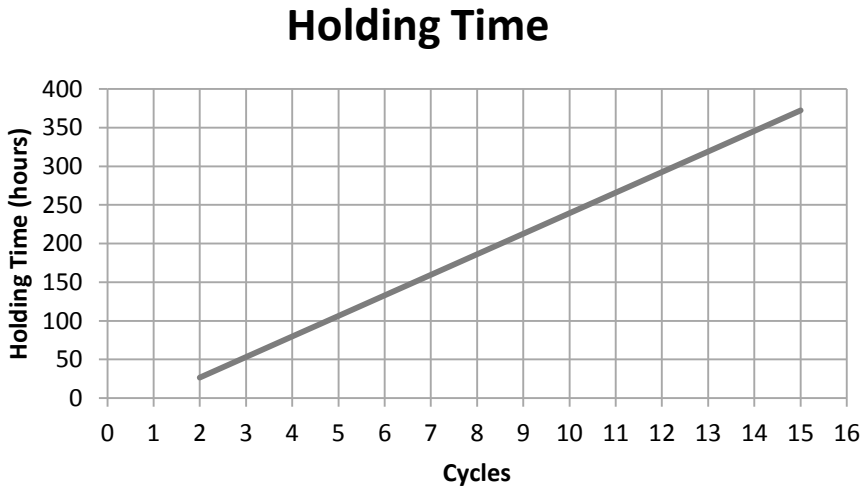
- Biofilm, in general, is comprised of mixed populations of bacterial cells within a fibrous matrix of ionic polymer (slime)



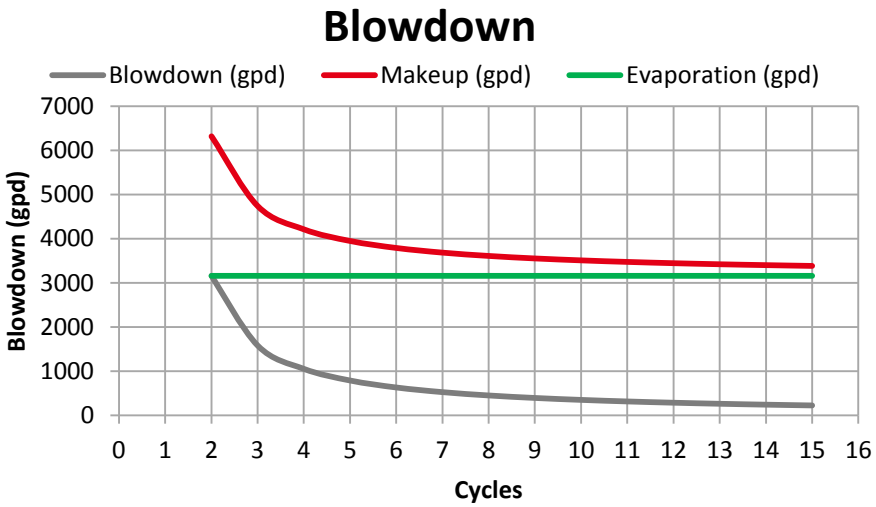
Holding Time Index or Half-life

- Important considerations for scale control:
  - Holding Time Index (HTI) is the turnover rate of water and constituents in a cooling tower circuit. It can be understood as the amount of time required to dilute added chemical to 50% of its original concentration:
  - $$\text{HTI} = \frac{0.7 \times \text{Volume of System (gallons)}}{\text{Blowdown Rate (GPM)}}$$
  - Organic chemicals such as phosphonates and polymers lose their effectiveness over time, so HTI needs to be considered when determining dosages and how effective they will be
  - In once through waters, the antiscalants and dispersants only have to be effective for a matter of seconds. In cooling towers, holding time can be hours to days or even longer so higher dosages are needed

Holding Time & Effects on Water Treatment Chemistry

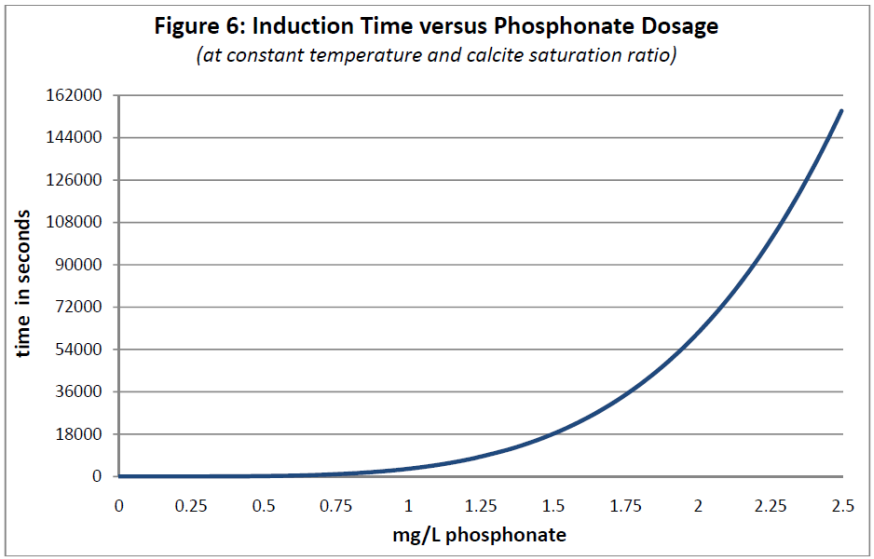


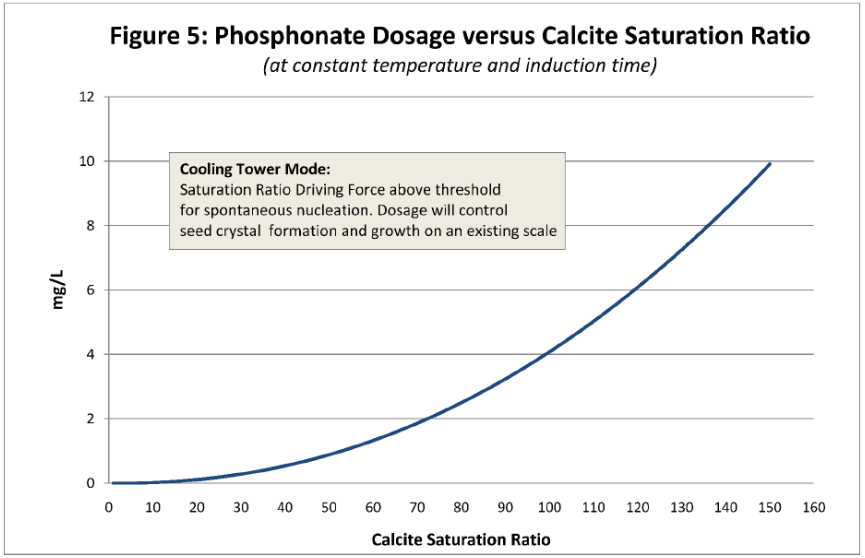
- As you can see, the cycling effect of a cooling tower system has a direct impact on water treatment considerations and must be balanced with economics to develop the best strategy for control



- As a rule of thumb, most cooling water treatment programs can be managed effectively when HTI is < 3 days

Induction Time – How Long Before Scale Occurs

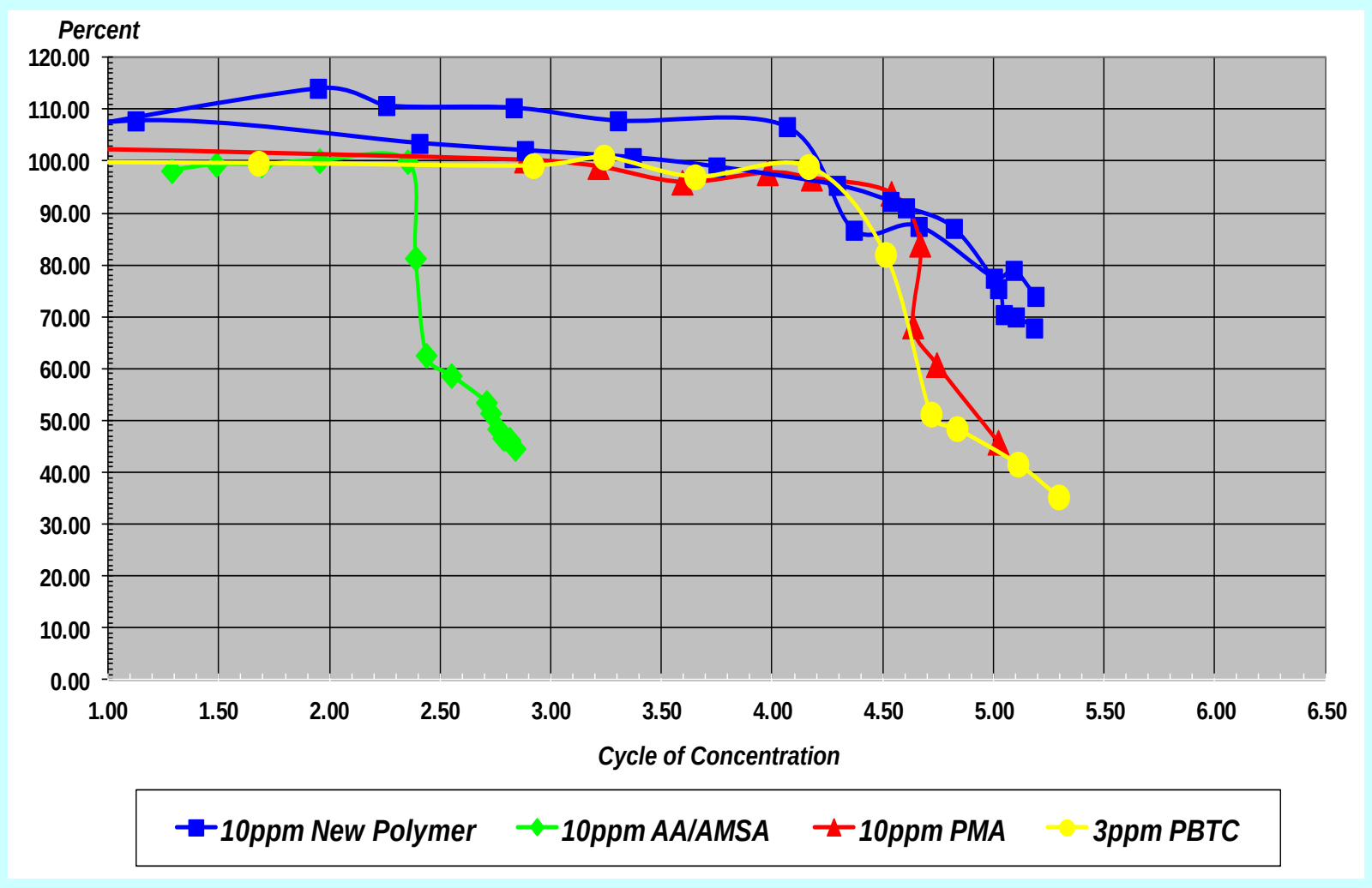




- The demand for phosphonate and polymers increases with an increase in HTI. They can delay scale, but not indefinitely
- Phosphonate concentrations in a cooling system are limited by saturation, degradation due to oxidant levels, hydrolysis, biological activity, and demand
- Polymers can be used to assist phosphonates in scale control and must be dosed appropriately

Ferguson, Robert J. "The Kinetics of Cooling Water Scale Formation and Control." *AWT Annual Meeting* Atlanta, GA Sept. 14-17, 2011

Calcium Carbonate Threshold Inhibition - pH 8.8



Power GEN & Heavy Industry Requirements

- High water temperatures and high heat exchanger skin temperatures require stronger scale and corrosion inhibition.
- Biofilm and bacteria control extremely important
- Greater stress requires high performance polymers
- Key Performance Indicators (KPIs) used to evaluate
- Good monitoring and control equipment
- Proper service and maintenance program

Chemical Treatment Strategy

- Anti-scalants for scale control
- Dispersants for scale, sludge, suspended solids fouling
- Corrosion inhibitors for mild steel, copper most generally, then others such as galvanizing or aluminum
- Organic dispersants and surfactants for system cleanliness and to assist in biocide treatment
- Biocides for MB control

Questions?

THANK YOU!

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