TAPPI

Kraft Recovery Course

Recovery Boiler Water Treatment

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Presented By

Sheppard T. Powell Associates, LLC

Baltimore Maryland
www.stpa.com

Presentation Format

- Objectives Of Treatment Program
- Steam/Water Cycle: Basic Components
- Top Routine Chemistry Parameters
- Summary

Objectives Of Treatment Program

Component	Deposit	Corrosion
Condensate System	--	Minor
Feedwater System	--	Minor
Boiler	Minor	0 or Minor
Superheaters	0	0
Turbines	0	0

Boiler Deposit Example

- Thick Nose Tube Deposits of Copper and Copper Oxides Over Mixed Iron Oxide, Hardness Phosphate and Carbon

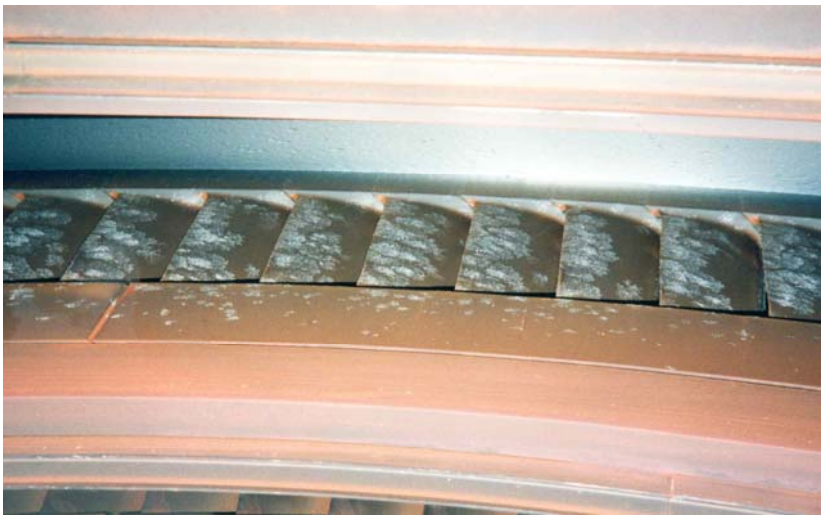
Boiler Blistering Example

Boiler Corrosion Example

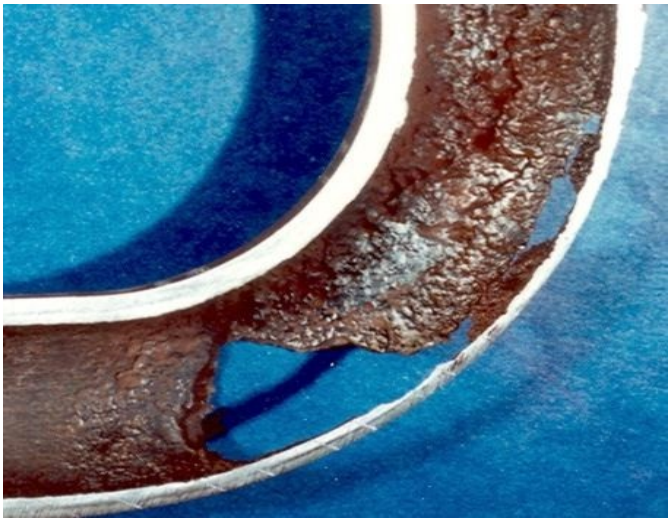
- Deposits After Brushing

- Under-Deposit Corrosion

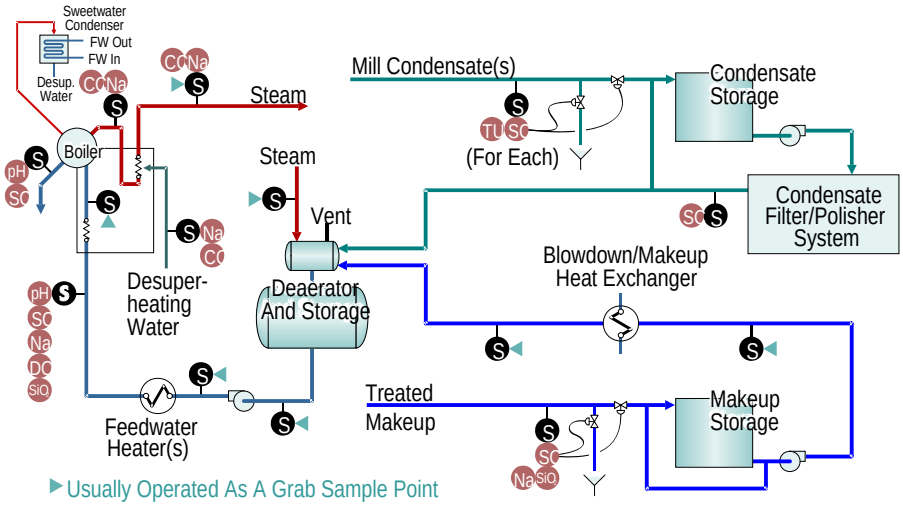
Turbine Deposits Example



Superheater Corrosion Example



Steam/Water Cycle Diagram



Questions

Specific Conductivity

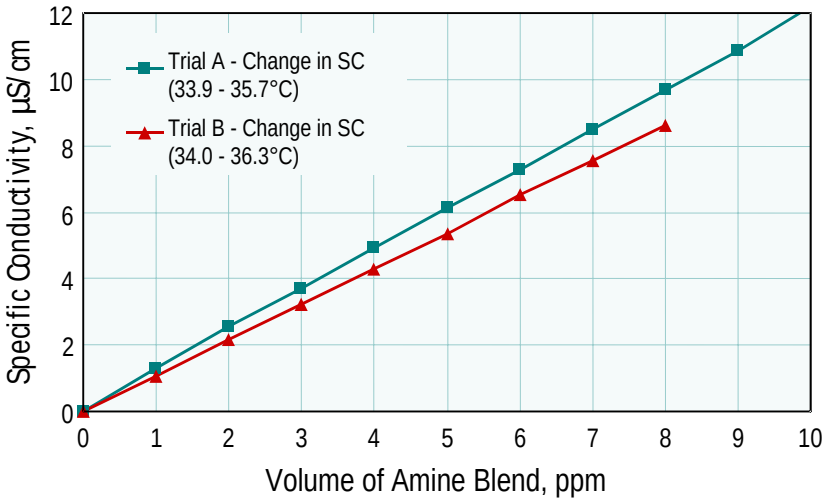
- Total Conductive Solids (Salts, Acids, Alkalis)
- High Levels Can Cause Foaming and/or Corrosion
- Units: Usually µS/cm
- Micromho (µmho/cm) = Microsiemen (µS/cm)
- Millimho (mmho/cm) = Millisiemen (mS/cm)
- 1 mS/cm = 1000 µS/cm (Beware of auto-switching ranges on meter!)

Specific Conductivity

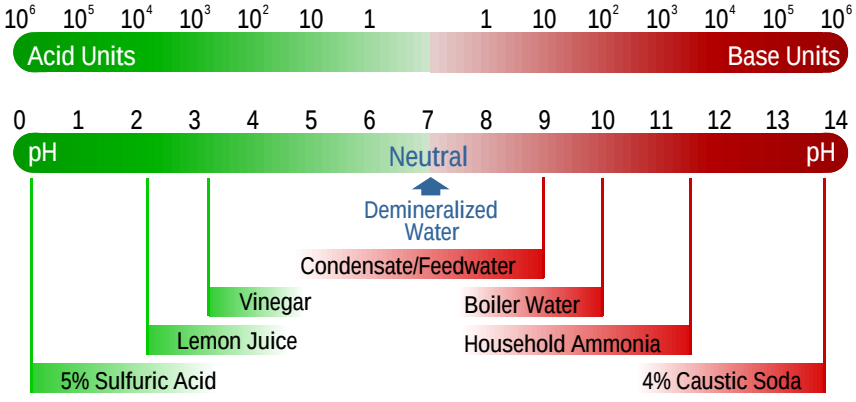
Sample	Normal Values, µS/cm	Main Source
Demineralized Water	0.05 – 5.0	NaOH Leakage
Condensate & Feedwater	2.0 – 6.0	Amine Feed
Boiler Water	20 – 150 (a)	3 to 5 × PO_4

(a) Much Higher For Low Pressure Boilers On Softened Makeup

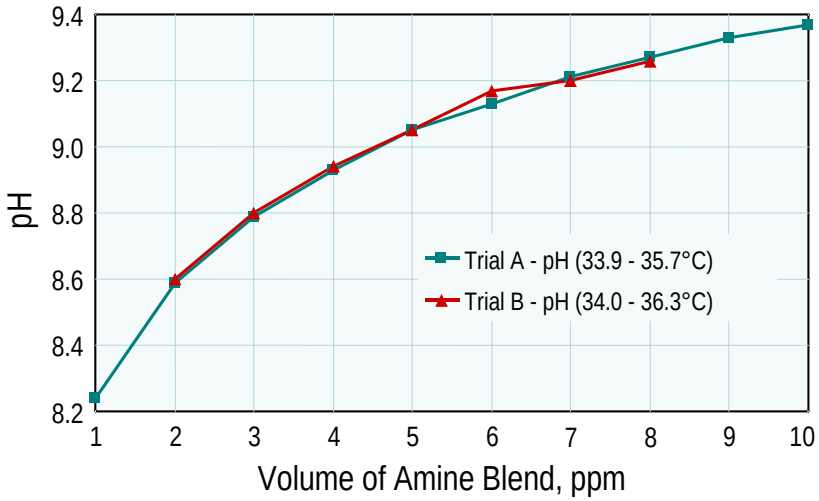
Example of Amine Blend Effect on Conductivity



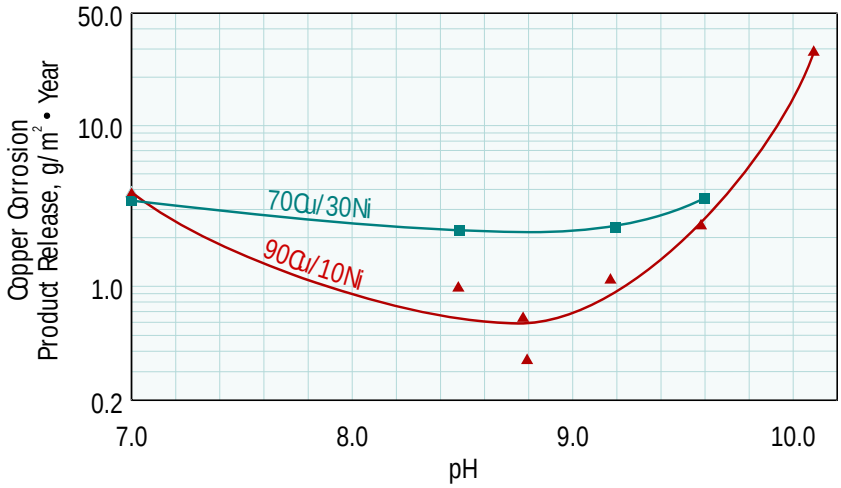
pH (Relative Acidity and Alkalinity)



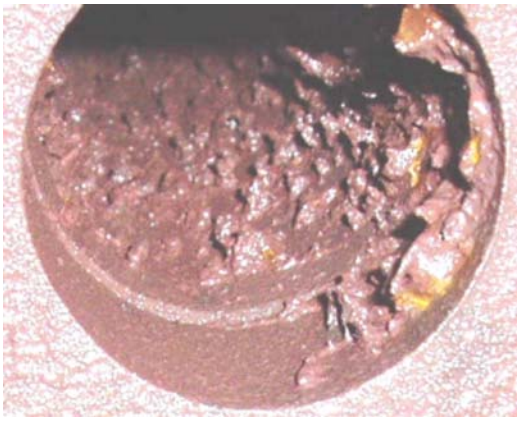
Example of Amine Blend Effect on pH



Effect of pH on Copper Transport

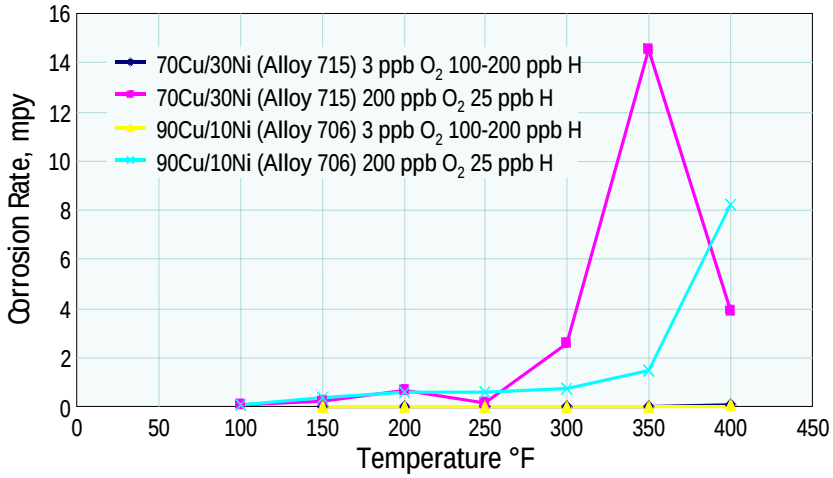


Dissolved Oxygen



- Oxygen as O_2 (from air) dissolved in water. Corrodes copper and steel (economizer shown).
- 1 ppm O_2 =
  1 mg/L =
  1000 ppb =
  1000 µg/L

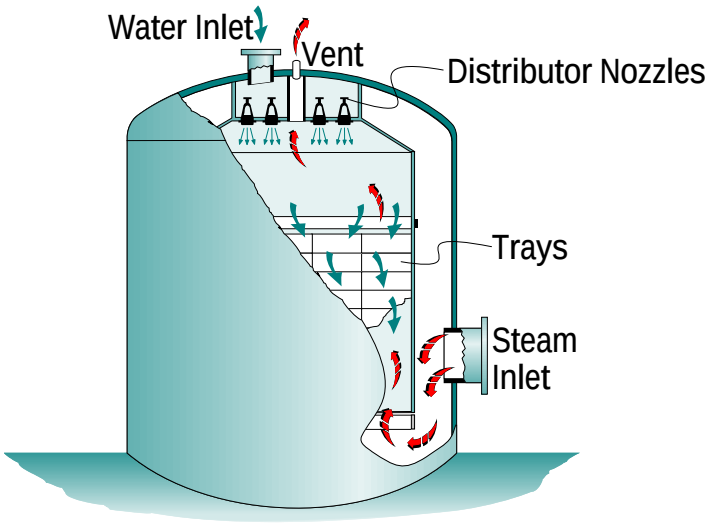
Dissolved Oxygen Effect on Copper Corrosion



Dissolved Oxygen

- Normal Values
  - Mill Water or Demineralized Water
    - Saturated (8,000 - 14,000 ppb)
  - Condensate: 10 - 100 ppb O_2
  - Feedwater: <5 - 10 ppb O_2
- Sources
  - Air Leaks
    - Where Water Leaks Out, Air Leaks In
  - Mill Water In-leakage
    - 0.1% Raw Water = 8 - 14 ppb O_2

Dissolved Oxygen Control: Deaerator



Deaerator Spray Nozzles And Trays

Oxygen Scavengers – Carbohydrazide Example

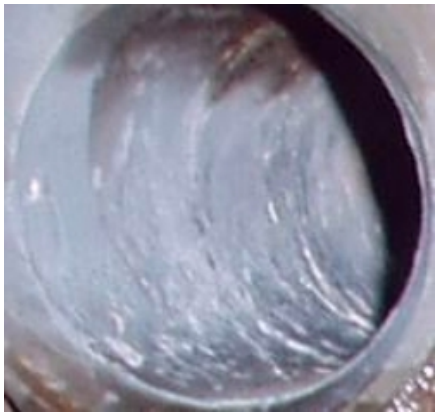
- Oxygen Scavenging (Reduces Oxygen)
  - Oxygen + Carbohydrazide → Inerts + Carbonic Acid
- Passivation
  - Red Rust + Scavenger → Black Rust + Carbonic Acid

Oxygen Scavenger Feed

- Underfeed
  - Copper Corrosion in Steam/Condensate System
  - Pitting of Economizer
- Overfeed
  - FAC: Flow Accelerated Corrosion and Rupture of Steel Pipe Lines (e.g., Feedwater Line)
  - Decomposition Products

Hardness In Generation Bank Tube

- Hardness Scale In Generation Bank Tube, Dispersant Treatment
- Without Dispersants, Gray Mayonnaise Deposits Are In Drums



Hardness – Definition

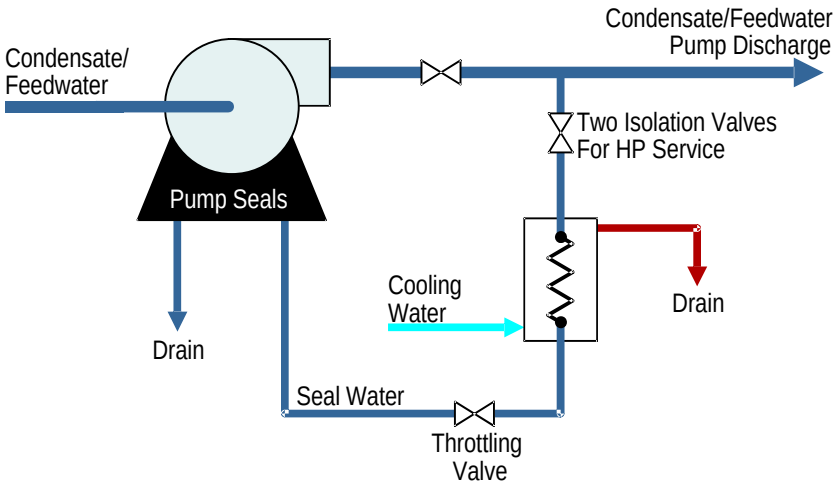
- Mainly the Calcium (Ca) and Magnesium (Mg)
- Precipitates and Forms Hardness Scale In Boiler
- Precipitation Can Result in Decreased Boiler pH

Hardness	+	Phosphate	→	Sludge	+	Salt	+	Acid
Calcium Sulfate	+	Sodium Phosphate	→	Calcium Phosphate	+	Sodium Sulfate	+	Sulfuric Acid
$3CaSO_4$	+	$2Na_2HPO_4$	→	$Ca_3(PO_4)_2$	+	$2Na_2SO_4$	+	H_2SO_4

Hardness - Limits

- Expected Values (ppm $CaCO_3$)
  - Feedwater and Turbine Condensate: 0.0
  - Process Condensate 0.0 – Trace
- Sources
  - Mill Water In Condensate/Feedwater
  - Problem In Makeup Demineralization System

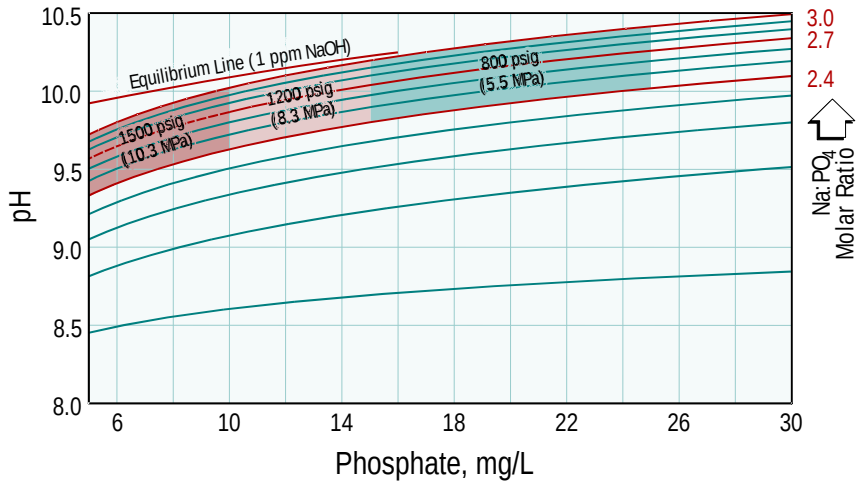
Control of Hardness: Prevent Intrusion



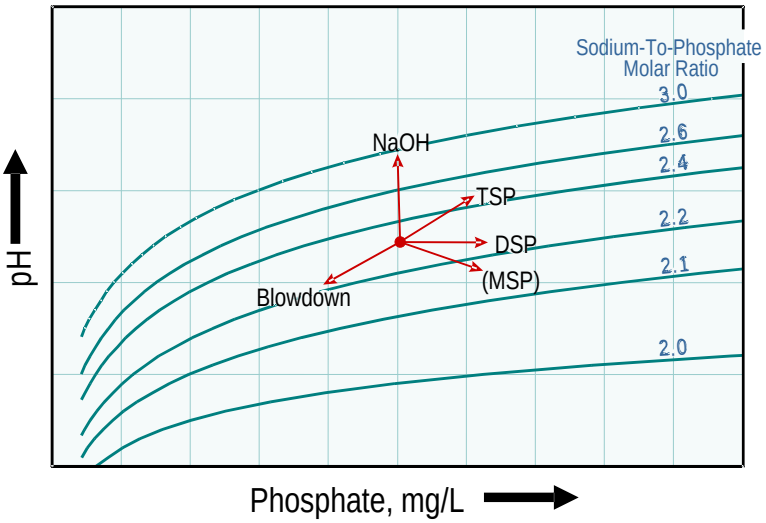
Phosphate (PO_4)

- Amount of Sodium Phosphate Dissolved in Boiler Water
- Units: ppm PO_4 = mg/L PO_4
- Purpose:
  - Stabilizes pH
  - Precipitates Hardness as Softer Deposits
  - Backup Indication of Hardness Contamination

Phosphate/pH Control Curves



Phosphate Effect on Boiler Water pH



Summary: What Should You Know?

- Top Chemistry Parameters in Steam/Water Cycle
  - Conductivity µS/cm
  - pH
  - Dissolved Oxygen, ppb O_2 (and Oxygen Scavengers)
  - Hardness, ppm $CaCO_3$
  - Phosphate, ppm PO_4
- Steam/Water Cycle, Basic Components
- Other (See Appendices)

Appendices

- A: Makeup Water Treatment
- B: Condensate Collection and Treatment
- C: Feedwater Treatment System
- D: Boiler Water Treatment
- E: Steam Purity Considerations
- F: Additional Chemistry Testing
- G: Preventive Maintenance
- H: Personnel Training
- I: Chemical Cleaning

For More Information

- TAPPI Technical Information Papers
  - WIS#3749036 – Water Quality and Monitoring Requirements for Paper Mill Boilers Operating on High Purity Water, 1999
  - WIS#3749037 – Design Engineer Decision Tree: Paper Mill Boiler Feedwater, 1999
  - WIS#3749038 – Response to Contamination of High Purity Boiler Feedwater, 2000
  - WIS#3749039 – Keys to Successful Chemical Cleaning of Boilers, 2000