Copper Turbine Deposits

Facts & Myths

How and Why?

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“Copper pickup, transportable to the turbines as a damaging deposit, originates in the high pressure feedwater heaters, and not in the condenser, or low pressure heaters ”

“Copper Turbine Deposits Can Be Controlled”
David E. Simon
Cyrus Wm. Rice & Co.
Power Magazine
February 1968

“The primary source of copper contamination of the fossil plant heat cycle is from copper alloy heaters, both low and high pressure.”

EPRI Technical Report 1000457
“Guidelines for Copper in Fossil Plants”
Section 5.1, page 93
November 2000

“Replacement of copper alloy tubing in the feedwater heaters is the optimum solution”

“Replacement of copper alloy condenser tubes……need not be done”

EPRI Technical Report 1000457
“Guidelines for Copper in Fossil Plants”
Section 8.4, page 175
November 2000

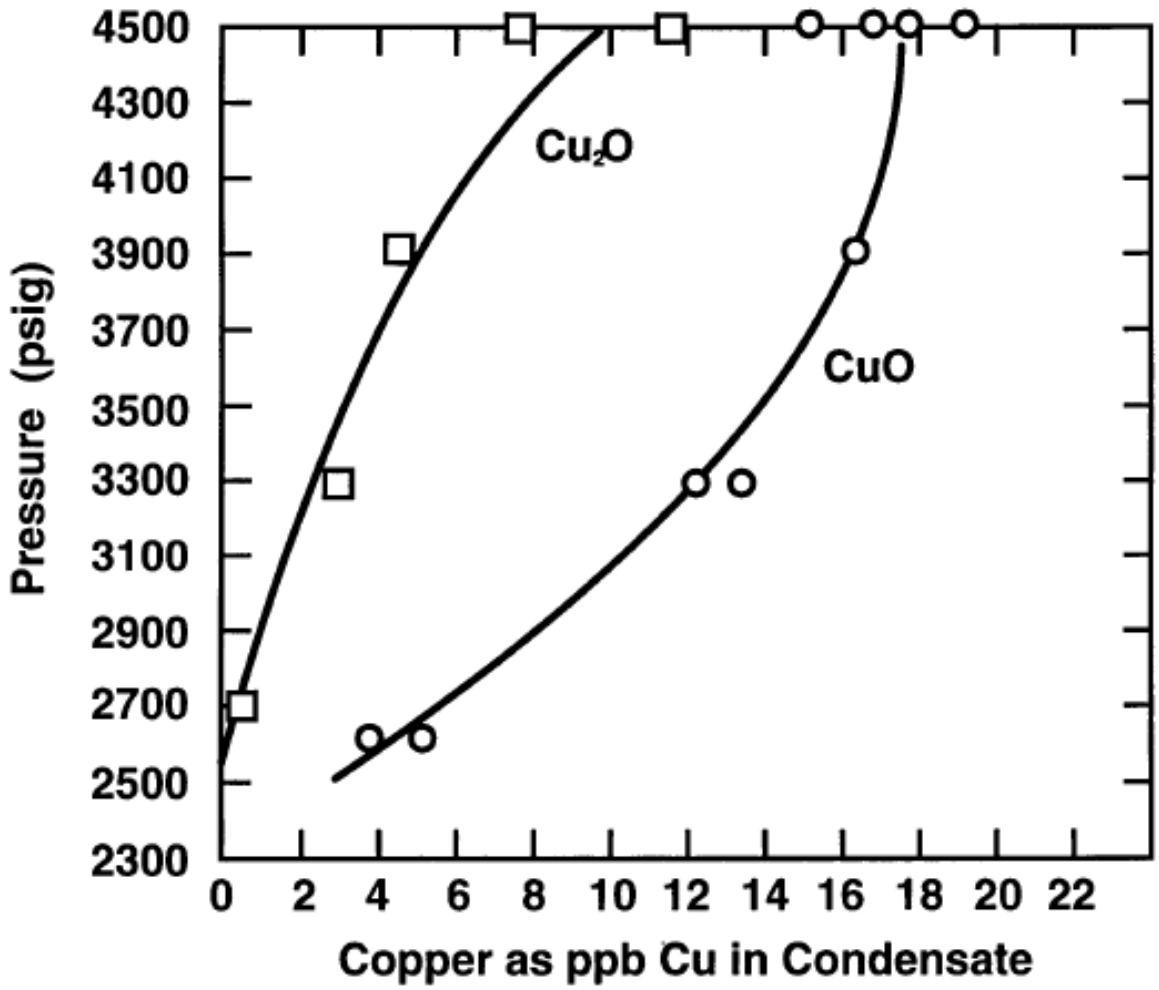
How and Why?

- **All metals corrode, or oxidize, in the presence of oxygen. In the case of copper alloys, cuprous and cupric oxide are formed. These oxides partition to the protective oxide film on the tube and to the feedwater.**
- **Oxide formation is accelerated with increased temperature and increased oxygen levels; and more oxides go into the feedwater.**

How and Why?

- **According to EPRI, “Only when the steam pressure is above about 2400 psi can the steam transport the copper, as a vaporous compound, into the HP turbine.”**

EPRI Technical Report 1000457
“Guidelines for Copper in Fossil Plants”
Abstract, page vii
November 2000



Solubility of cuprous and cupric oxides in superheated steam as a function of pressure. Abstracted from data by Pocock and Stewart.

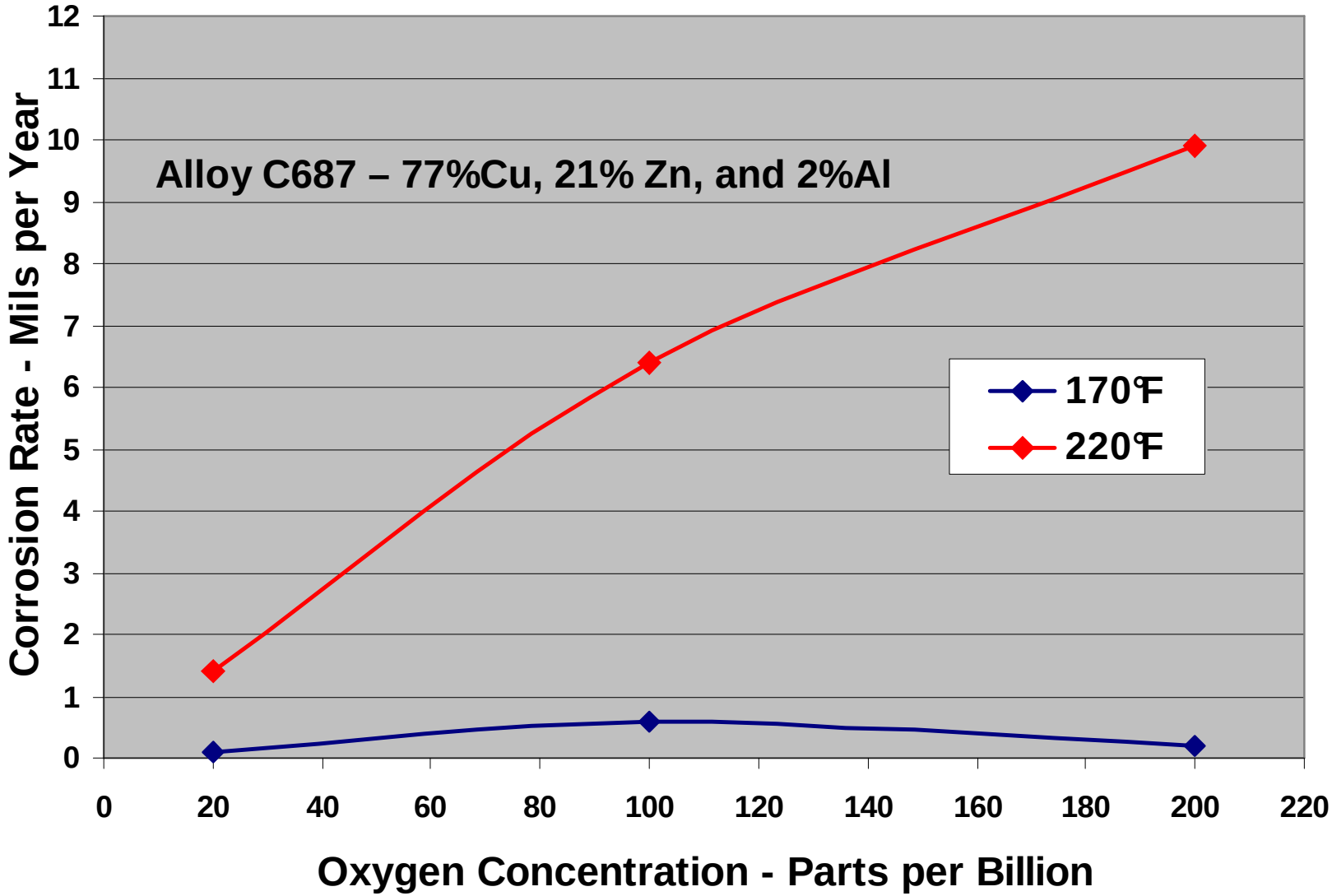
- **The primary contributing factors are high temperature, high dissolved oxygen, and boiler pressures greater than 2300 psi.**
- **As a practical matter, most “subcritical” fossil plants shouldn’t experience copper turbine deposits, even with copper alloy feedwater heater tubes.**
- **However, the potential for excursions in pressure and oxygen control support EPRI’s position on replacing copper alloy feedwater heater tubes.**

Condenser and Feedwater Heater Operating Conditions

	LP Heater	HP Heater	Condenser ARS	Condenser Main Body
Temperature	77-400 ℉	350-1000 ℉	77-125 ℉	77-125 ℉
Pressure	200-700 psi	400-3500 psi	Near Vacuum	Near Vacuum
NH_3 in ppm	0.1-10 ppm	0.1-10 ppm	< 200 ppm	< 5 ppm
pH	8.8-9.6	8.8-9.6	8.8-9.6	8.8-9.6
O_2 in ppb	5-150 ppb	5-150 ppb	≤ 200 ppb	≤ 10 ppb

The feedwater heater environment is harsh compared to the condenser environment; temperature differences are very significant!

OXYGEN & TEMPERATURE EFFECTS ON CORROSION



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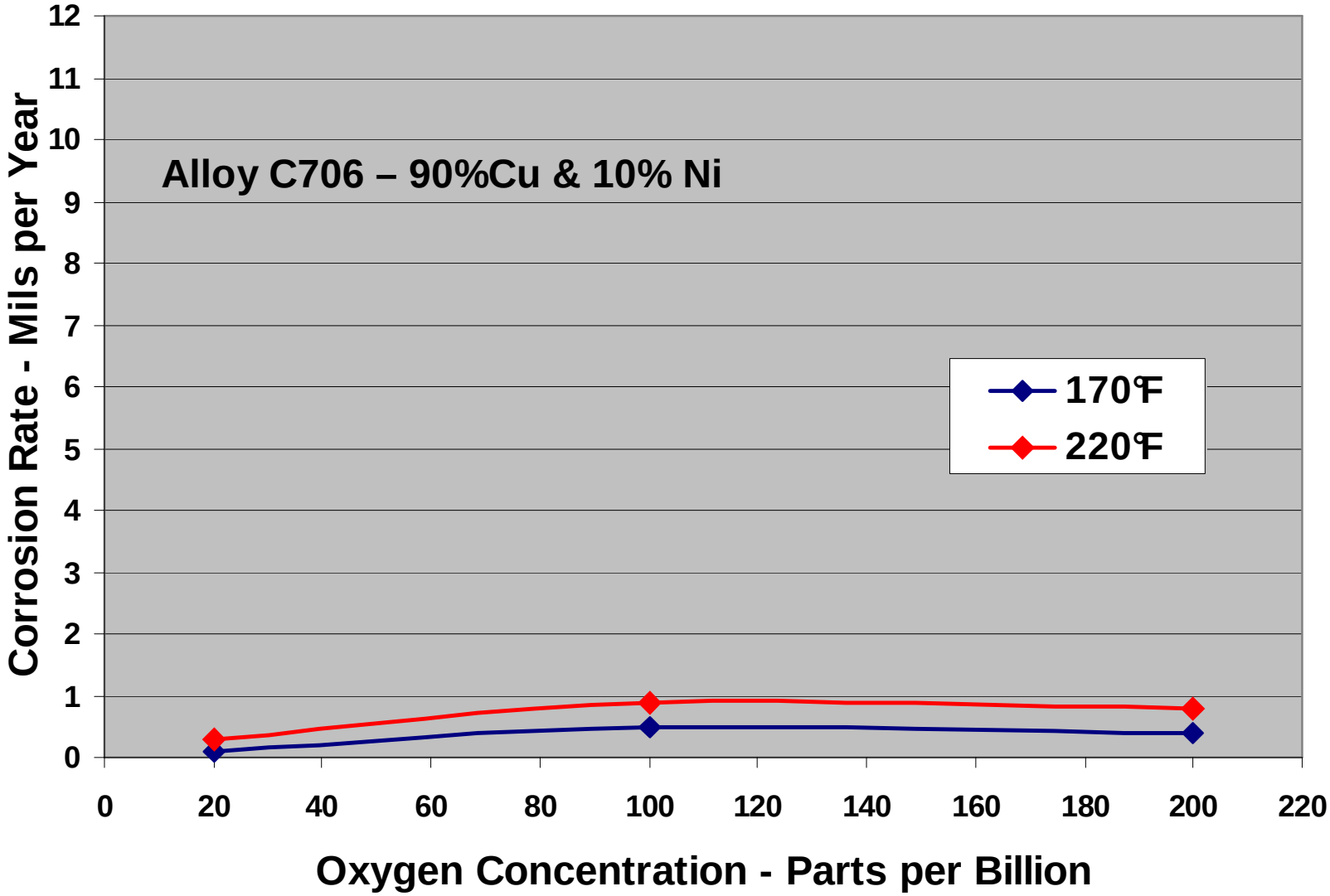
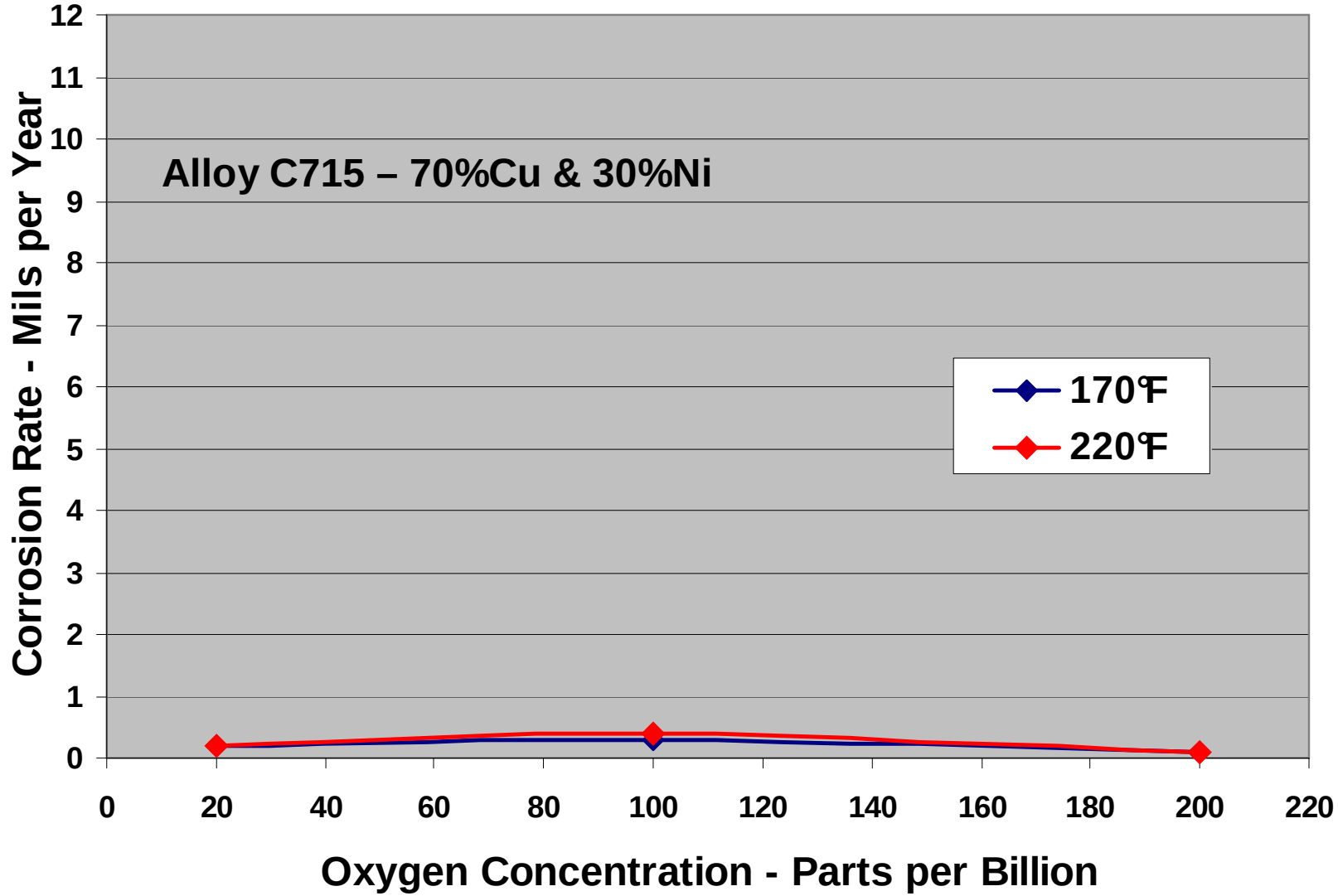


OXYGEN & TEMPERATURE EFFECTS ON CORROSION



What About Supercritical Fossil Units with Boiler Pressures >> 2400 psi ?

- **Feedwater heaters don't have copper.**
- **State-of-the-art "mixed bed" condensate polishers remove copper in addition to iron oxides, sulfates, sodium, silica, and chlorides**

The Condensate Polisher is your Insurance Policy!

Plant Survey Results

- **Two 600 MW coal-fired units – Wisconsin – 1980**
  - ***90-10 Cu-Ni Condenser Tubes / Stainless FW Heater Tubes***
  - ***1800 psi Boiler Pressure***
  - ***No Copper Carryover / No Corrosion Problems***
- **Five unit fossil plant (125-200 MW) – Ohio - 1953**
  - ***90-10 Cu-Ni Condenser Tubes / Ferrous FW Heater Tubes***
  - ***No Copper Carryover or Deposits***
- **Six "Supercritical" units in AEP System**
  - ***Copper Alloy Condenser Tubes / Ferrous FW Heater Tubes***
  - ***No Copper Carryover or Deposits***

Chemistry Guidelines for Mixed Metallurgy Systems

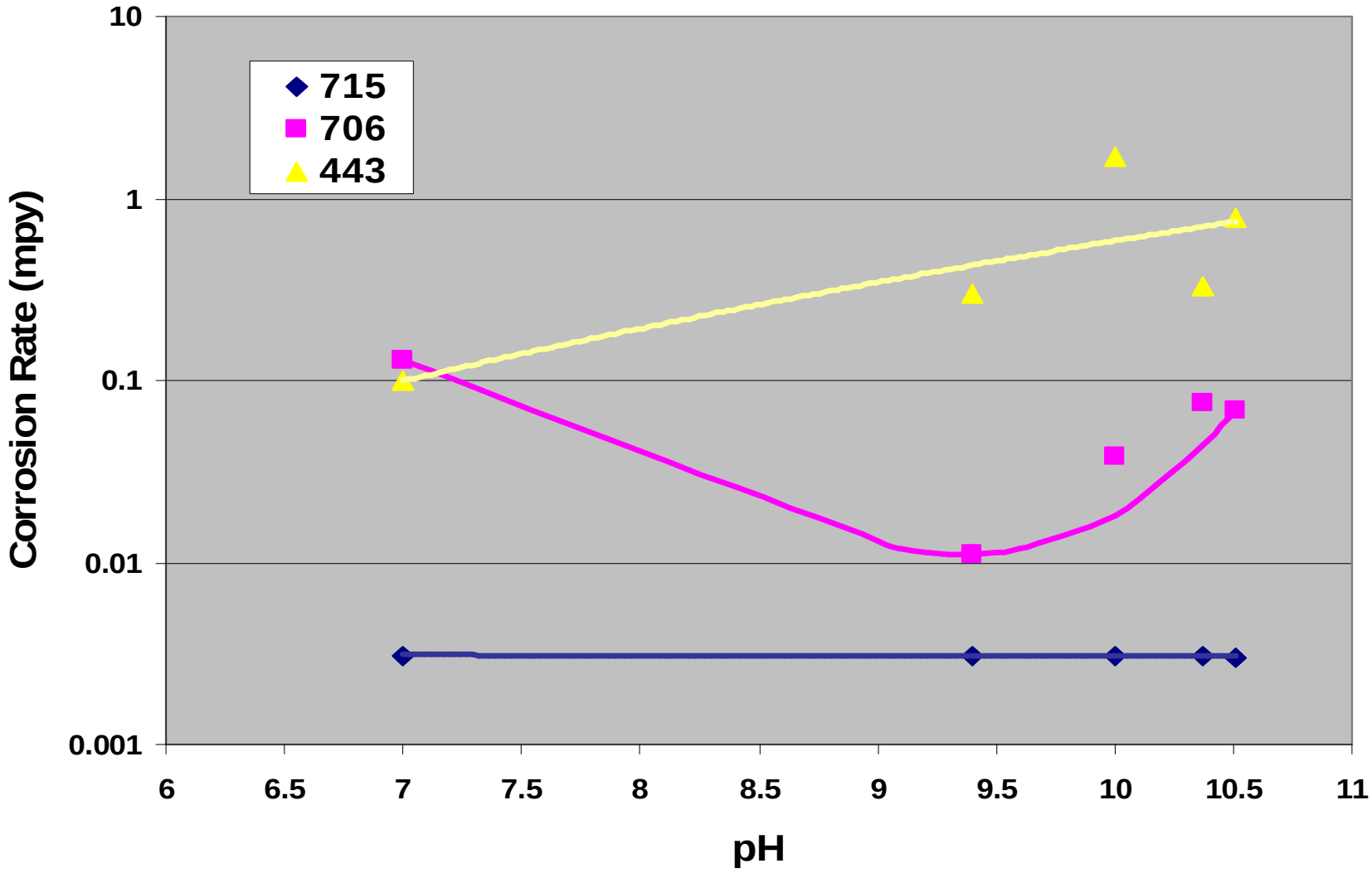
Cycle Chemistry Parameter	Recommended Range
pH	8.8 – 9.1
Ammonia	0.15 – 0.4 ppm
Oxygen	< 5 ppb

EPRI Technical Report 1000457
"Guidelines for Copper in Fossil Plants"
Table 1-2, page 39
November 2000

“Copper nickel alloys, particularly the 90-10 material, are most stable around a pH of 9.3.”

Flow-Accelerated Corrosion; A Critical Issue Revisited,
Brad Buecker,
Power Engineering, July 2007

Effect of pH on Corrosion



Summary & Conclusions

- **Feedwater Heaters with copper alloys are the primary source of Copper Turbine Deposits; avoid the use of copper alloys in feedwater heaters.**
- **Copper oxides are not transportable as vaporous compounds at boiler pressures less than 2400 psi; copper turbine deposits should not occur in “subcritical” fossil plants.**
- **Copper alloy condenser tubes can be used in “subcritical” fossil plants.**

Summary & Conclusions

- **Copper alloy condenser tubes are used successfully in "supercritical" fossil plants because those plants have ferrous feedwater heater tubes and condensate polishers.**
- **A system pH range of 9.2-9.6 can be used if copper-nickel is used in the air removal section of the condenser.**
- **Copper alloys should be used in the condenser to take advantage of their better heat transfer and biofouling resistance.**