EFFECTS OF USING THE AIR HEATER FOR SO_3 REMOVAL

John Guffre
Paragon Airheater Technologies
WWW.PARAGONAIRHEATER.COM

Benefits of an Air Heater

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- Accounts For ~10% - 15% Of a Unit's Thermal Efficiency

- Reduces Fuel Cost By $10,000,000 Per Year on a 500 MW Unit

Gas Outlet Temperature

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- **ESTABLISHED STANDARD :**
  - A 10°F Increase In Gas Outlet Temperature Decreases Boiler Efficiency By 0.25%
  - 10°F Increases Fuel Cost By $ 500,000^{+}/Yr

Gas Outlet Temperature

PARAGON Airheater Technologies

GOAL:

Operate At Lowest Practical Gas Outlet Temperature

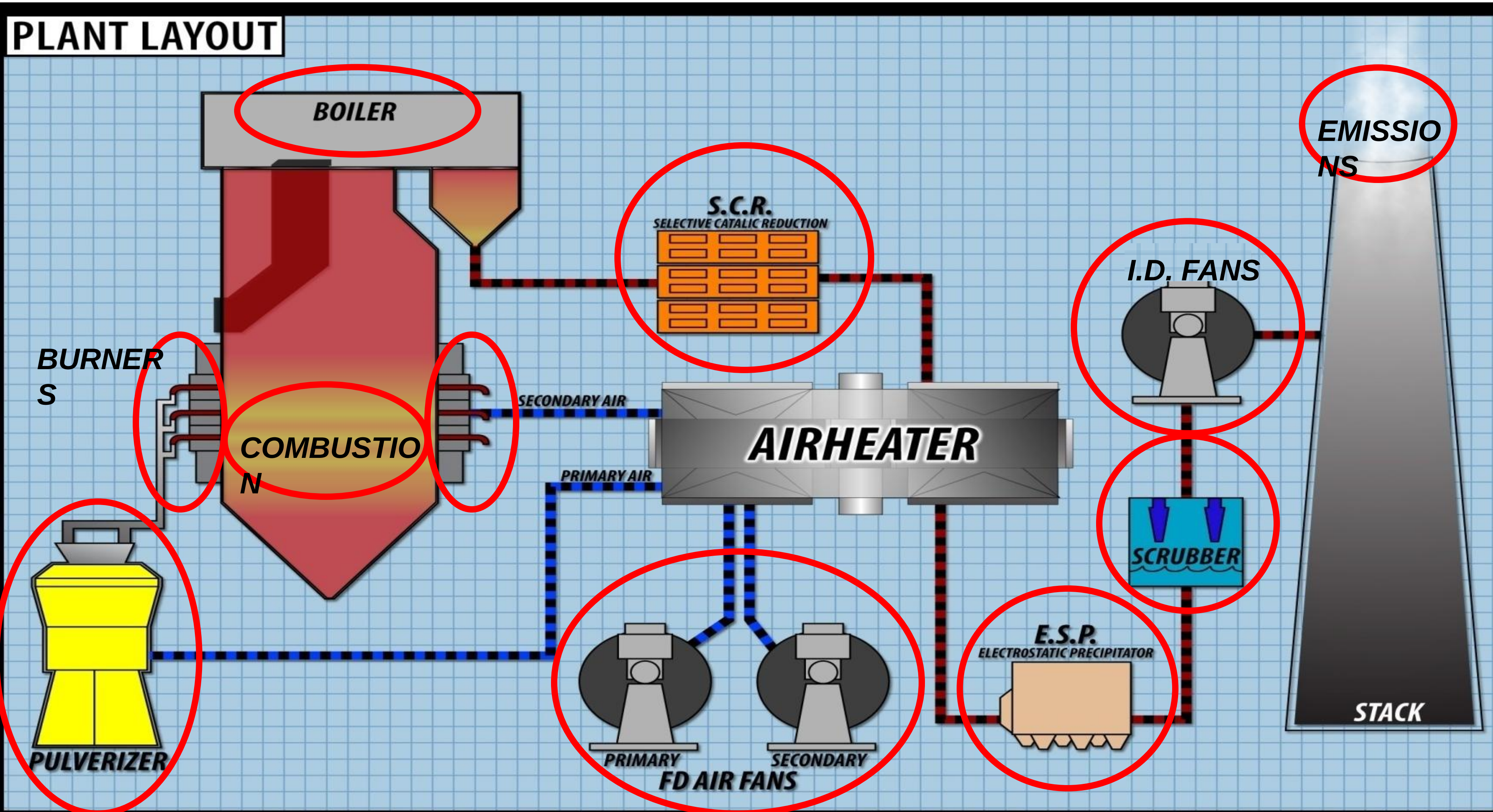
OBSTACLES:

Condensables

Effects of Gas Temperature on Equipment

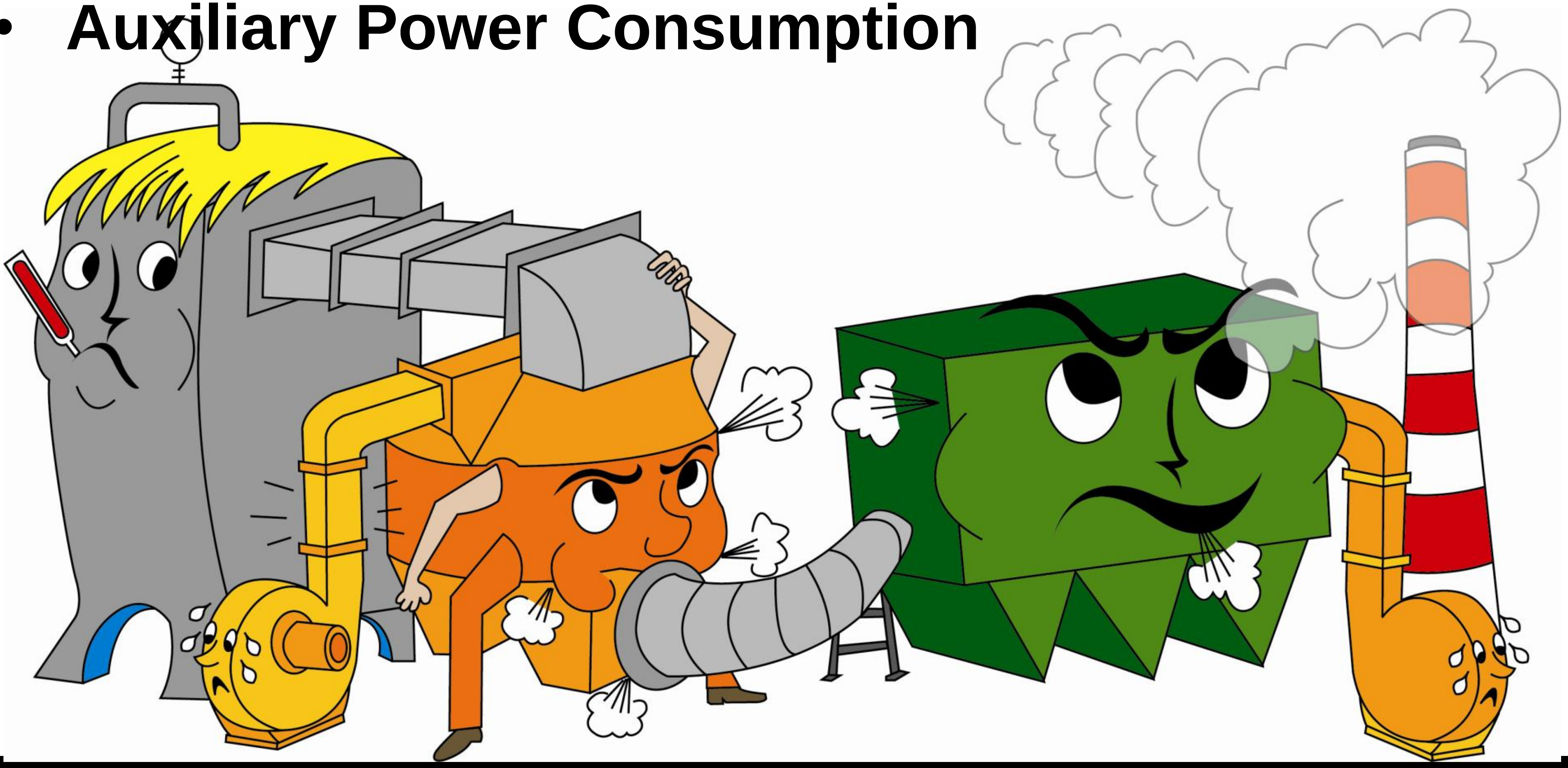
The SCR Impacts the Air Heater

The Air Heater Impacts Combustion and APC Equipment



Inter-Relationships

- **Combustion Performance**
- **APH performance**
- **Environmental Control Equipment**
- **Auxiliary Power Consumption**



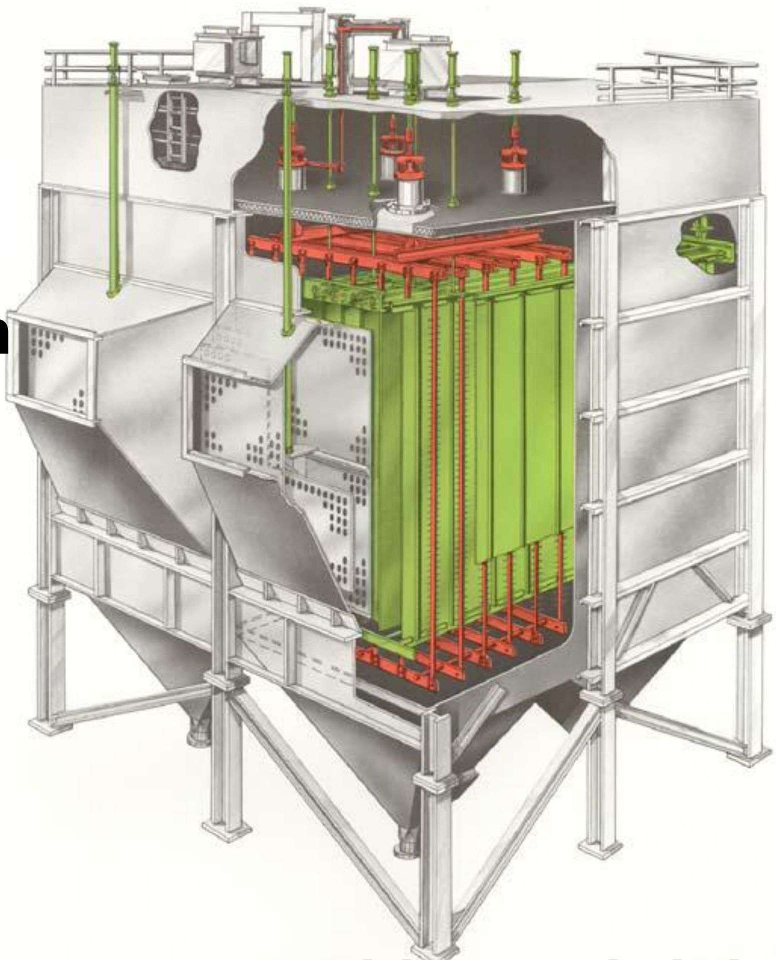
Electrostatic Precipitator(ESP) Challenges

Air Heater Leakage:

- Increased Gas Volume
- Reduced SCA
- Temperature and Flow Stratification
- Can Reduce Collection Efficiency Over 1%

Air Heater Efficiency Deterioration:

- May Result from ABS Plugging or Sorbent
- Increased Gas Temperature
- Increased Fly Ash Resistivity
- Increased Gas Volume
- Decreased SCA

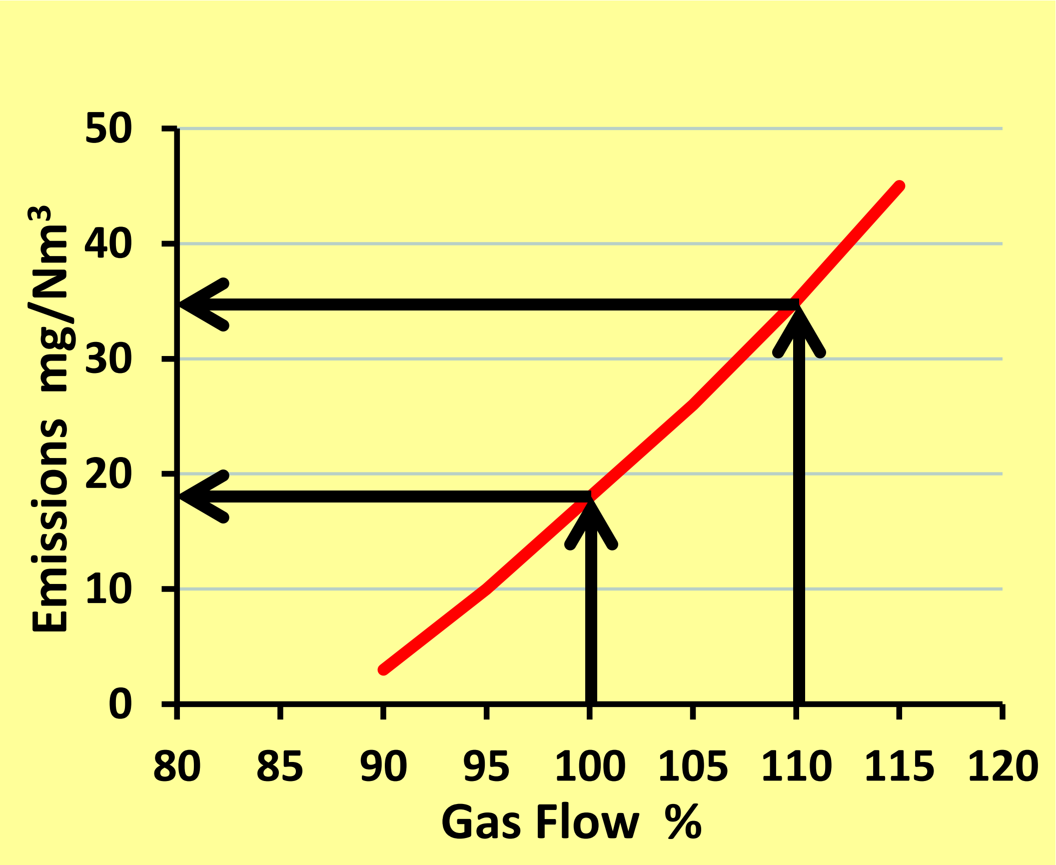


Air Heater Problems Shrink t
Relative Size of an ESP

Reducing Leakage Reduces ESP Emissions

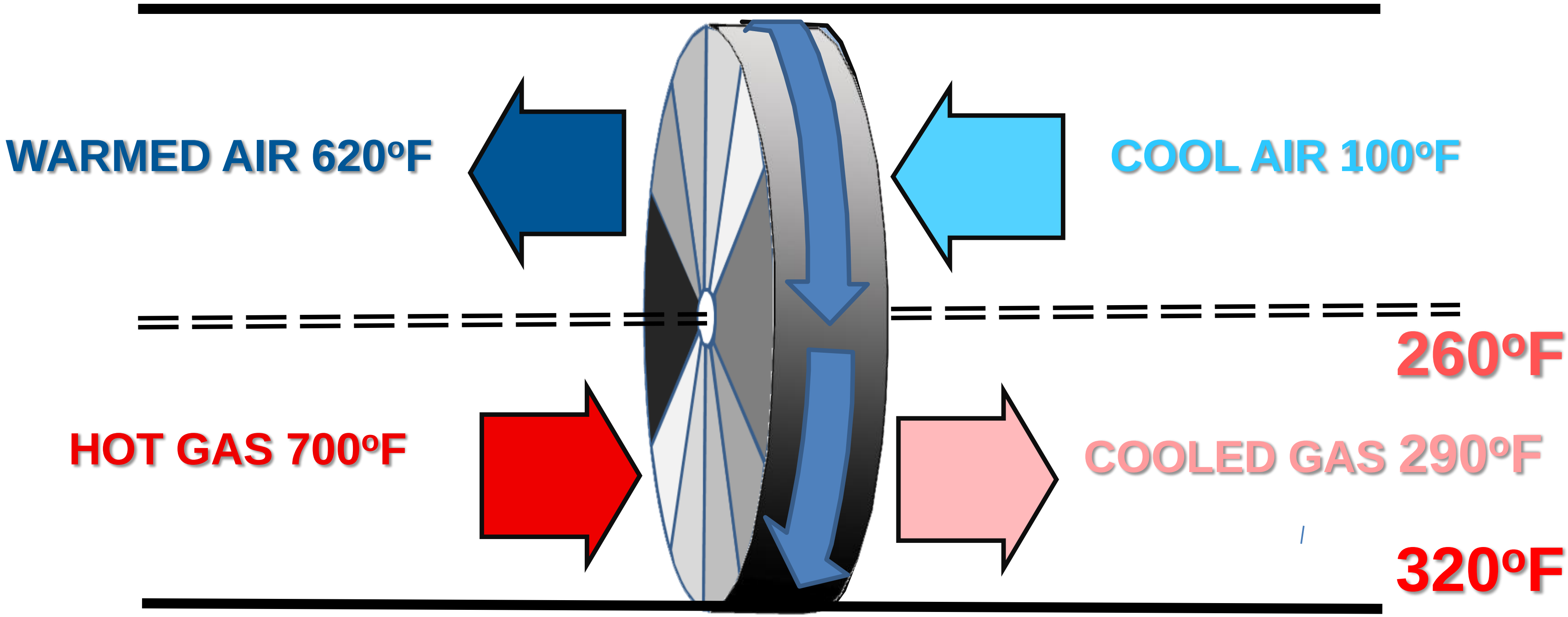
A 10% Leakage Reduction =

- 10% Decrease in Flue Gas Volume
- 10% Increase in SCA
- Lower Gas Velocity Through ESP
- Decreased Particulate Emissions

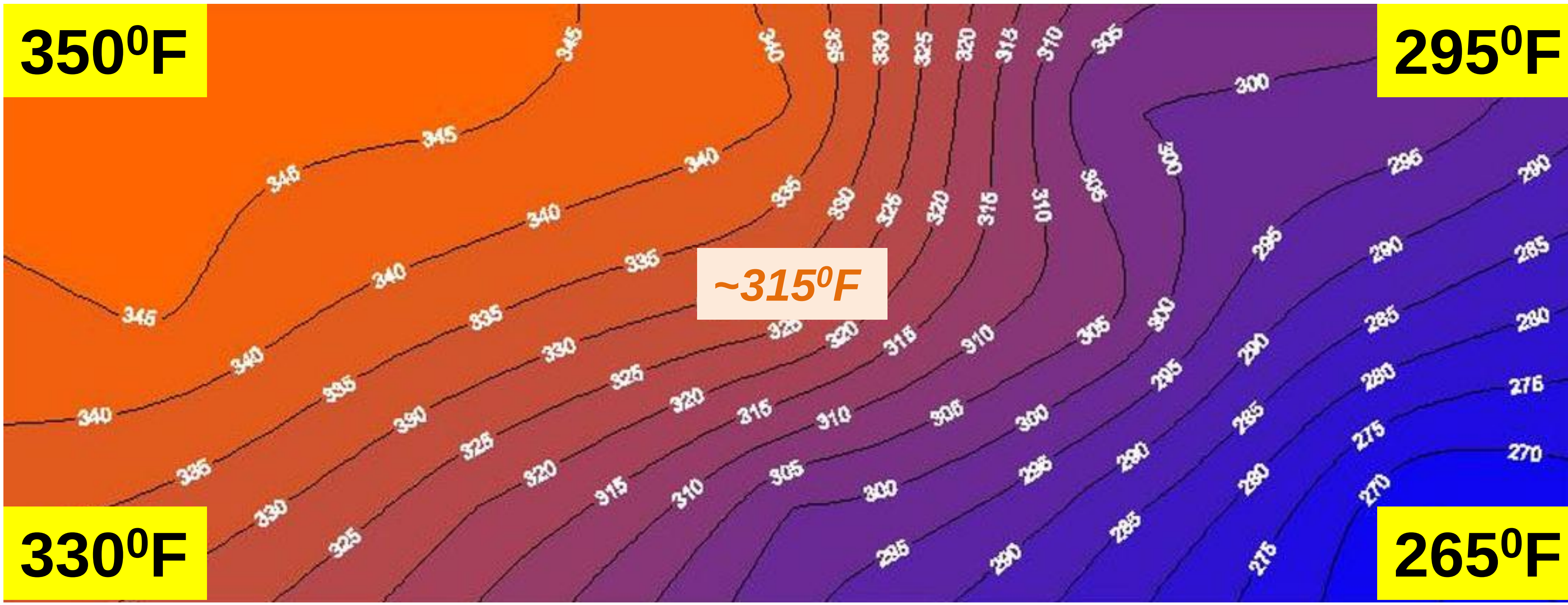


Function of an Air Heater

- Extracts Waste Heat From Exhaust Gases
- Recycles That Heat to the Incoming Air



GAS TEMPERATURE PROFILE



SO_3 EQUILIBRIUM

$$SO_2 + O + ☺ \rightarrow SO_3 + ☺$$

$$SO_3 + O \rightarrow SO_2 + O_2$$

SO_3 REMOVAL TEMPERATURES

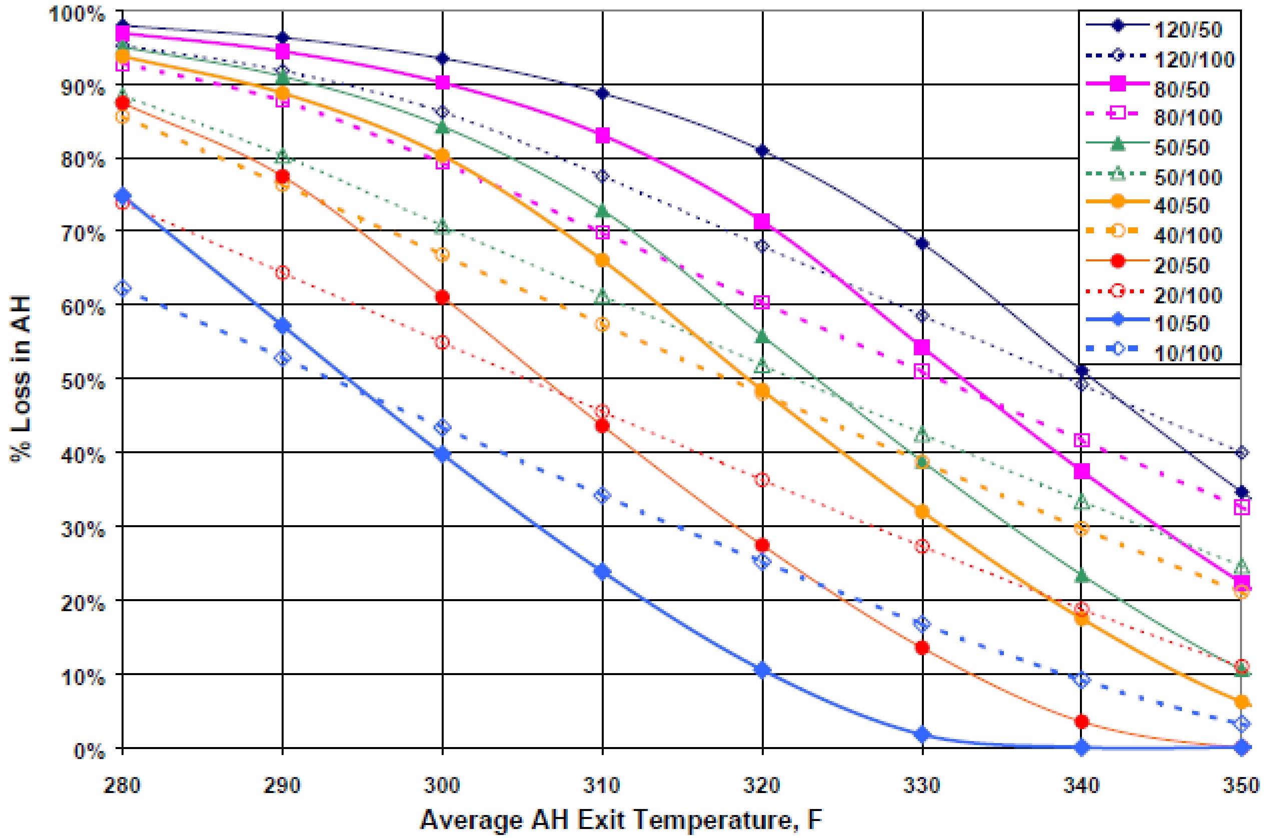


Figure 6.1. Estimated SO_3/H_2SO_4 losses across combustion air preheaters versus average air preheater exit temperature for a temperature offset of 35 °F. The first value of each pair in the legend is the preheater inlet SO_3/H_2SO_4 concentration in ppm and the second value of the pair is the spread in exit gas temperature between the cold side and the hot side of the preheater exit.

SO_3 EXIT CONCENTRATION

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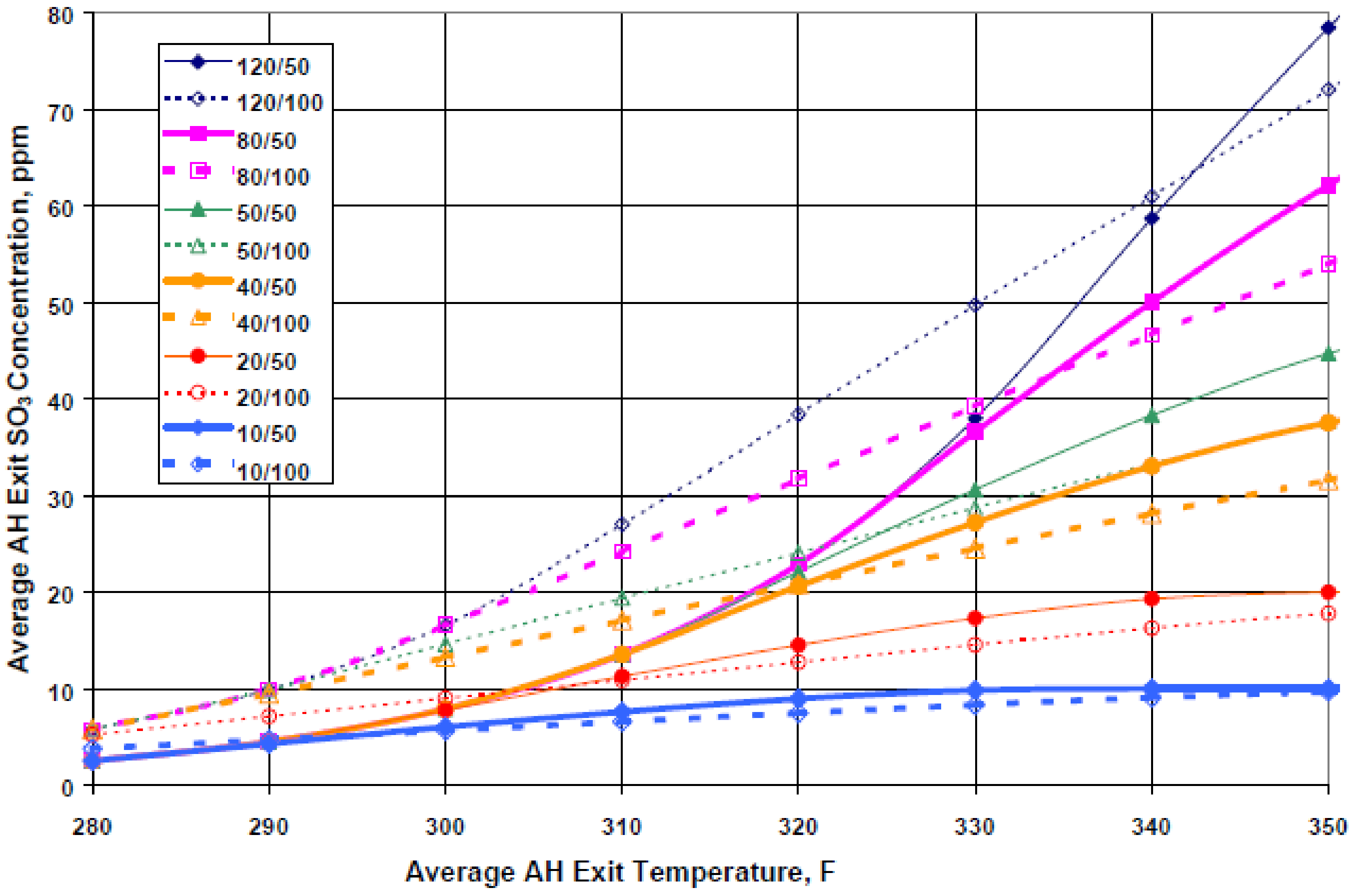

Figure 6.2. Estimated air preheater exit SO_3/H_2SO_4 concentration versus average air preheater exit temperature for a temperature offset of 35 °F. The first value of each pair in the legend is the preheater inlet SO_3/H_2SO_4 concentration in ppm and the second value of the pair is the spread in exit gas temperature between the cold side and the hot side of the preheater exit.

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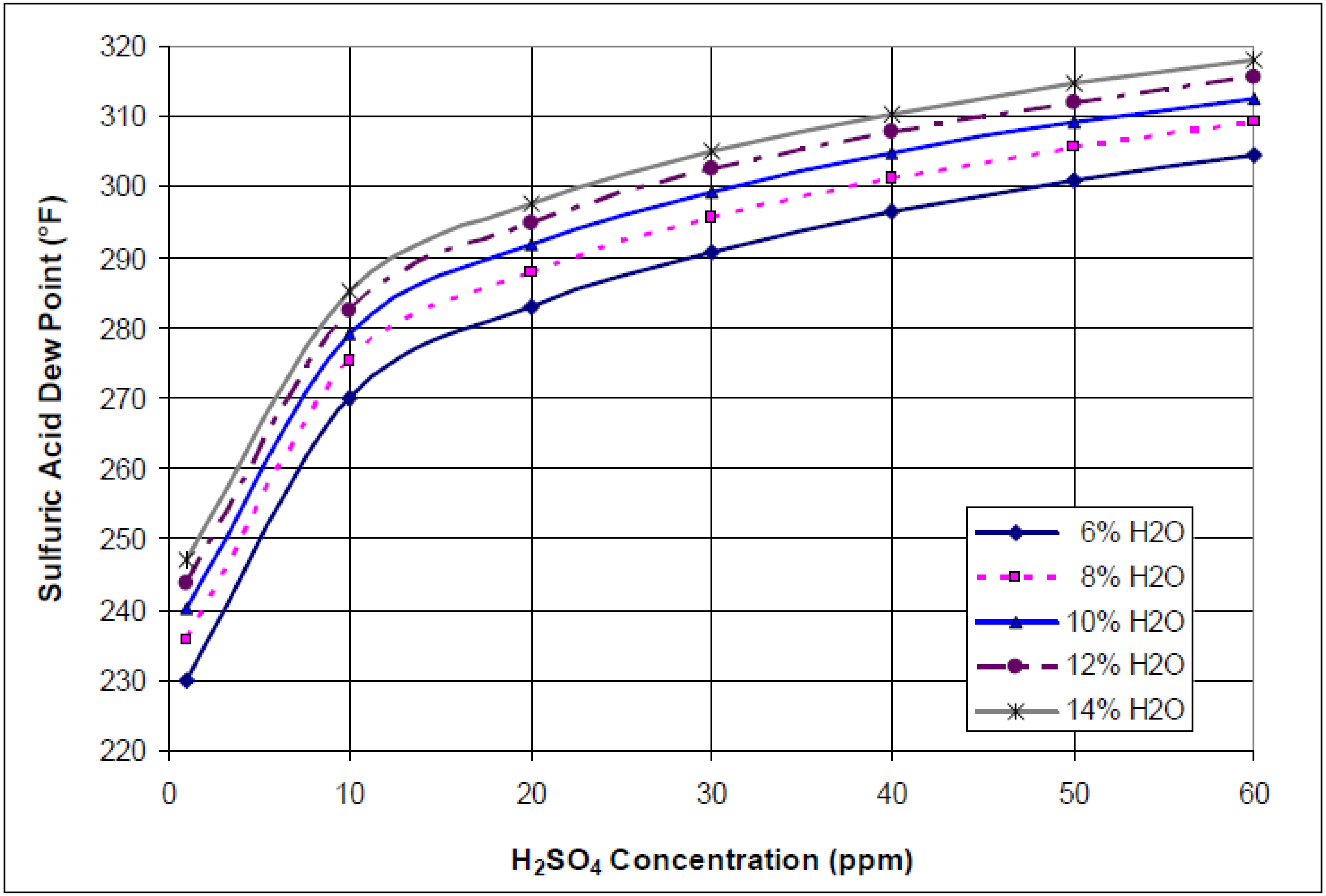
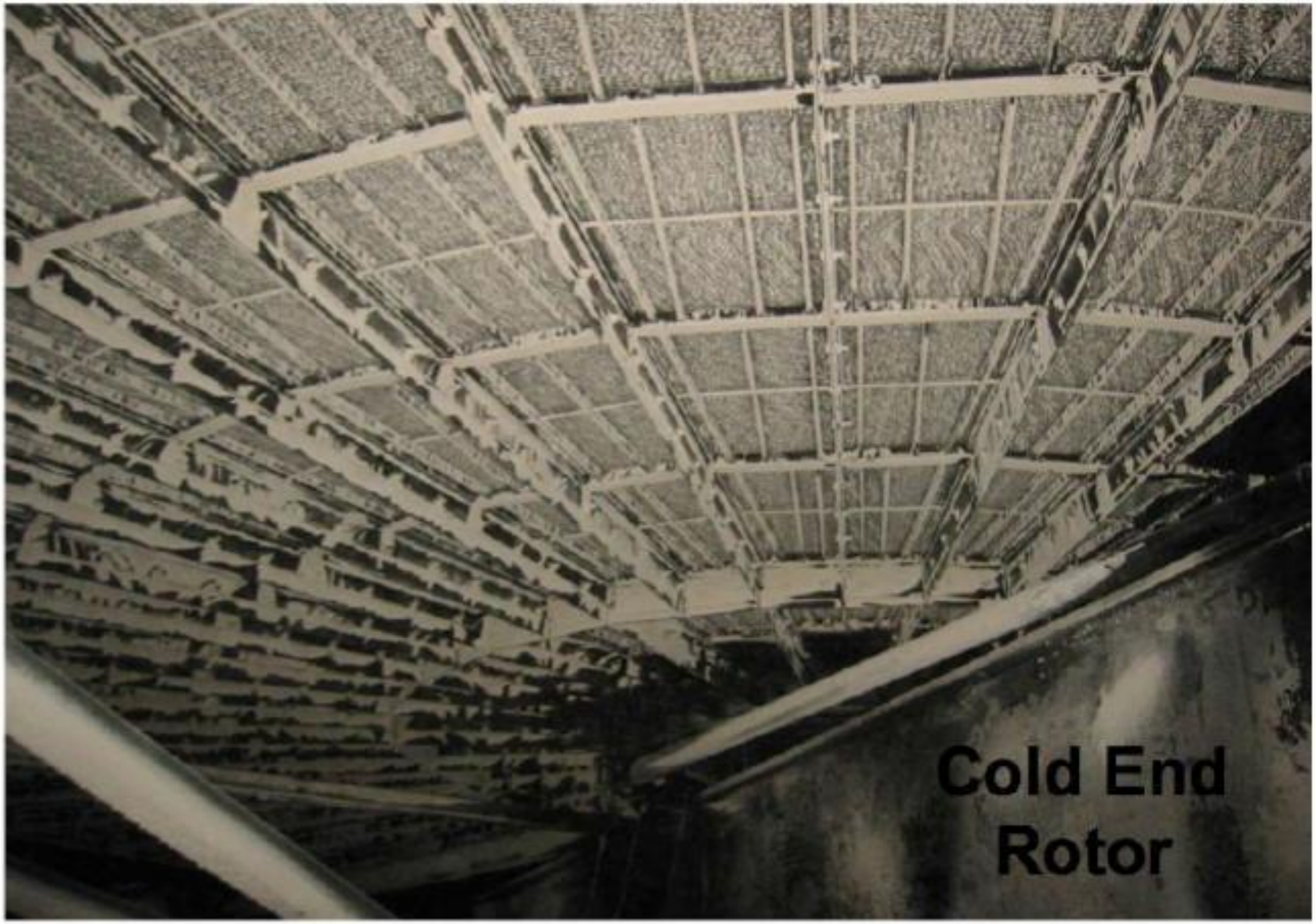
SO_3 Vs. Sulfuric Acid Dew Point Temp.



Ref. A&WMA, 2008 Mega Symposium,

"The Effect of SO_3 Sorbents on Electrostatic Precipitator Performance", Paper

Condensation Deposits



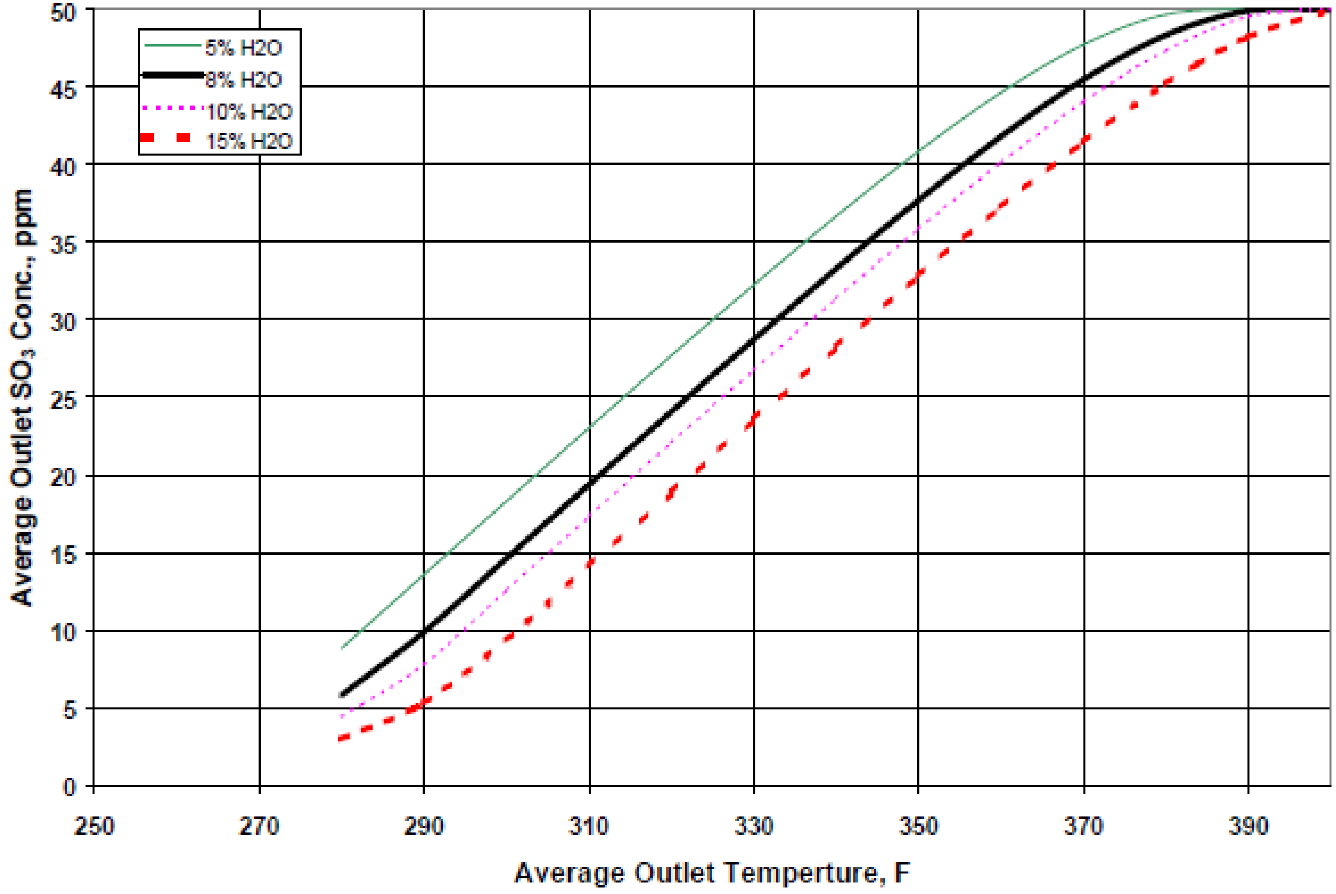
COLD END CORROSION

ACID RESISTANT COATINGS

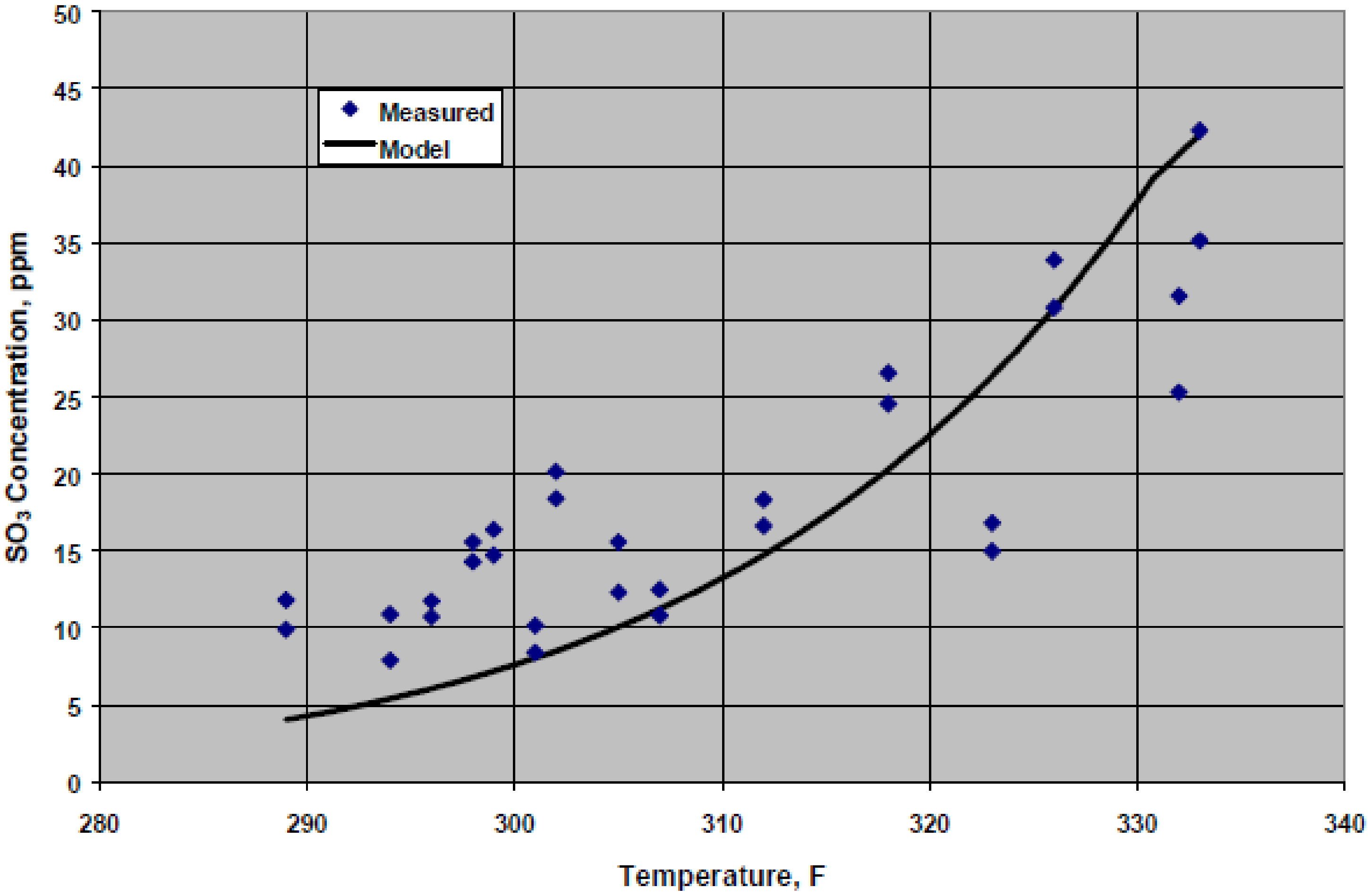
PICK YOUR CORROSIVE

Downstream Corrosion

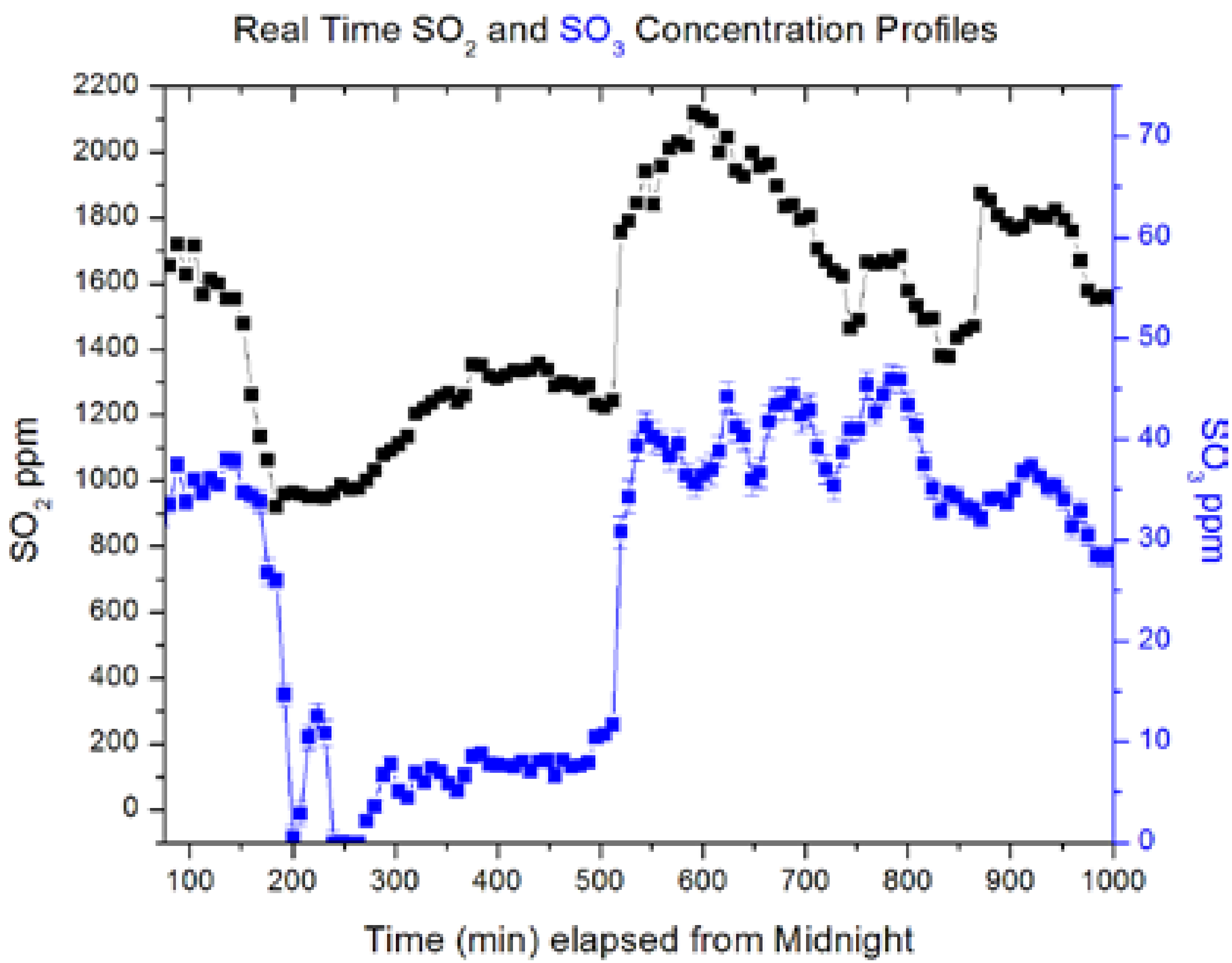
EFFECT OF MOISTURE ON SO_3 REMOVAL



AH SO_3 REMOVAL-TEST VS MODEL



SO_3 Variation with Load and SO_2



SO_3 Affects ESP Efficiency (Resistivity)

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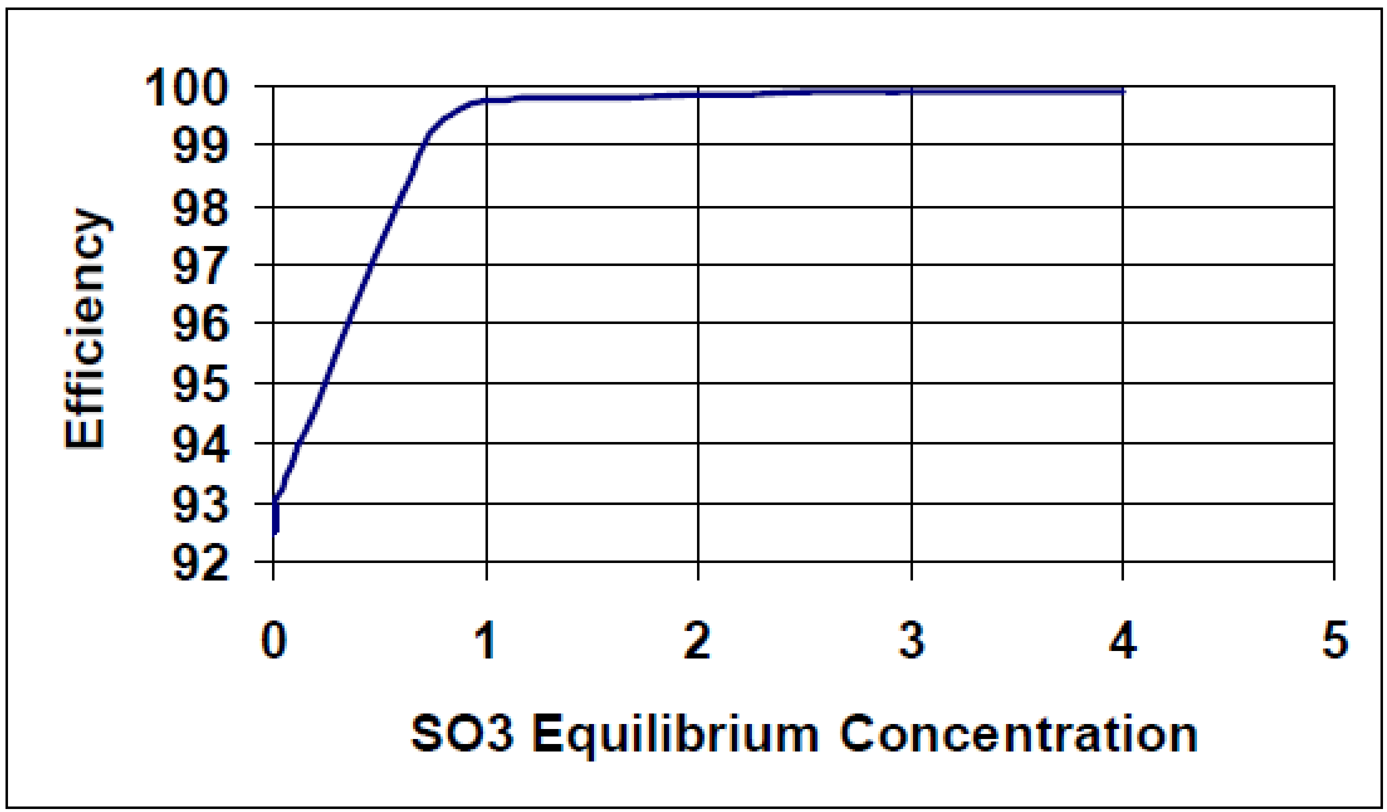
Precipitator Efficiency vs. SO_3 for ESP of 325 SCA



SO_3 Exiting the Air Heater

SO3 at AH Gas Inlet

Metal Temperature

Gas Temperature

Ash Quantity

Ash Alkalinity

PM 2.5

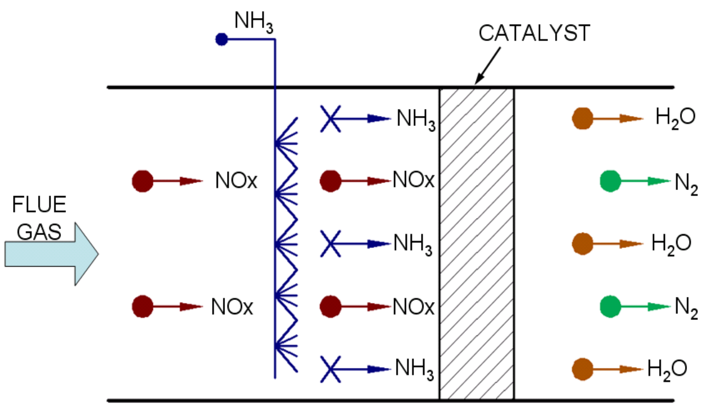
SO_3 - Central To Air Heater Limits

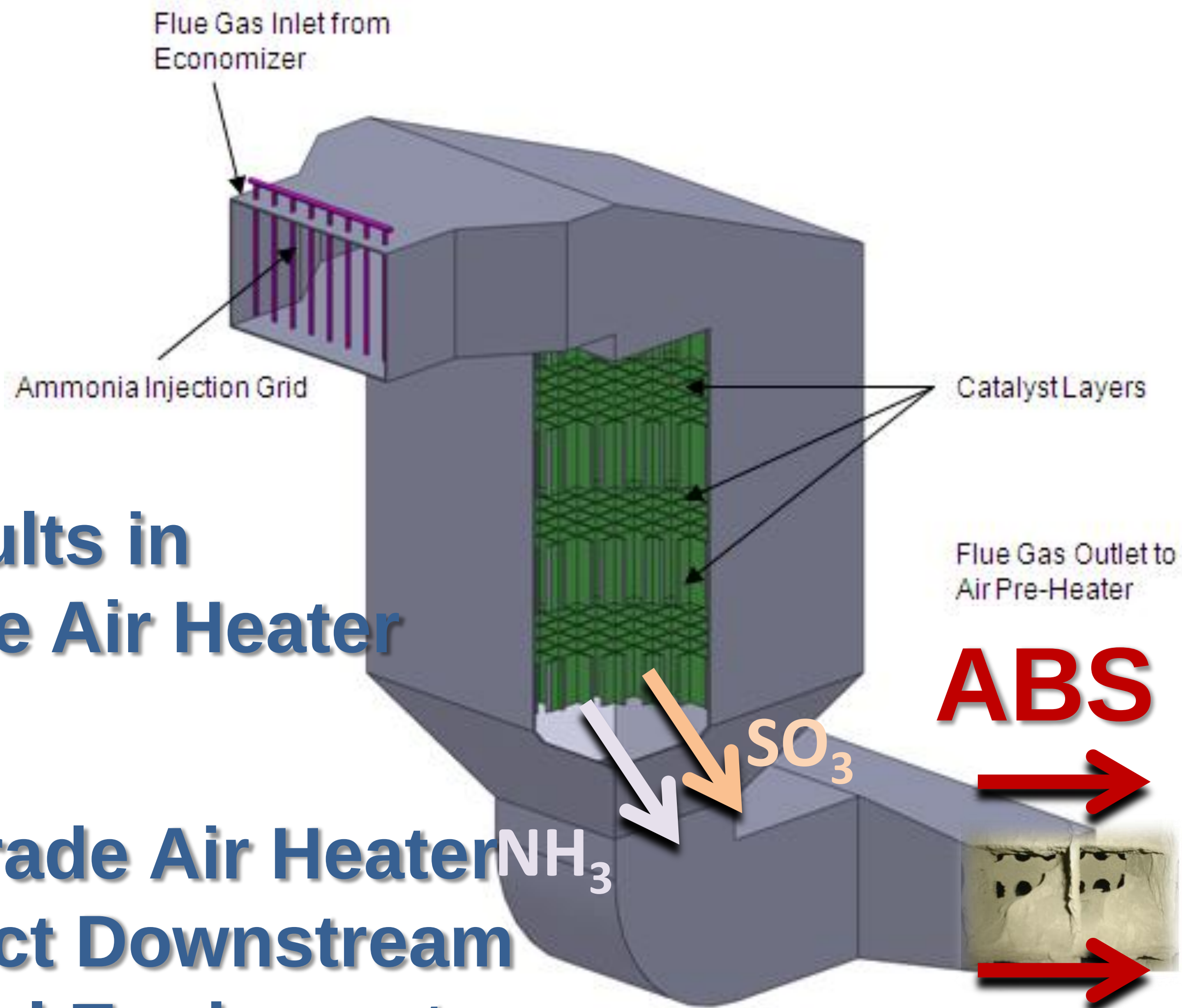
$$SO_2 + \tfrac{1}{2} O_2 \Leftrightarrow SO_3$$

$$SO_3 + H_2O \Leftrightarrow H_2SO_4$$

$$H_2SO_4 + NH_3 \Leftrightarrow (NH_4)HSO_4$$

SCR (Selective Catalytic Reduction)

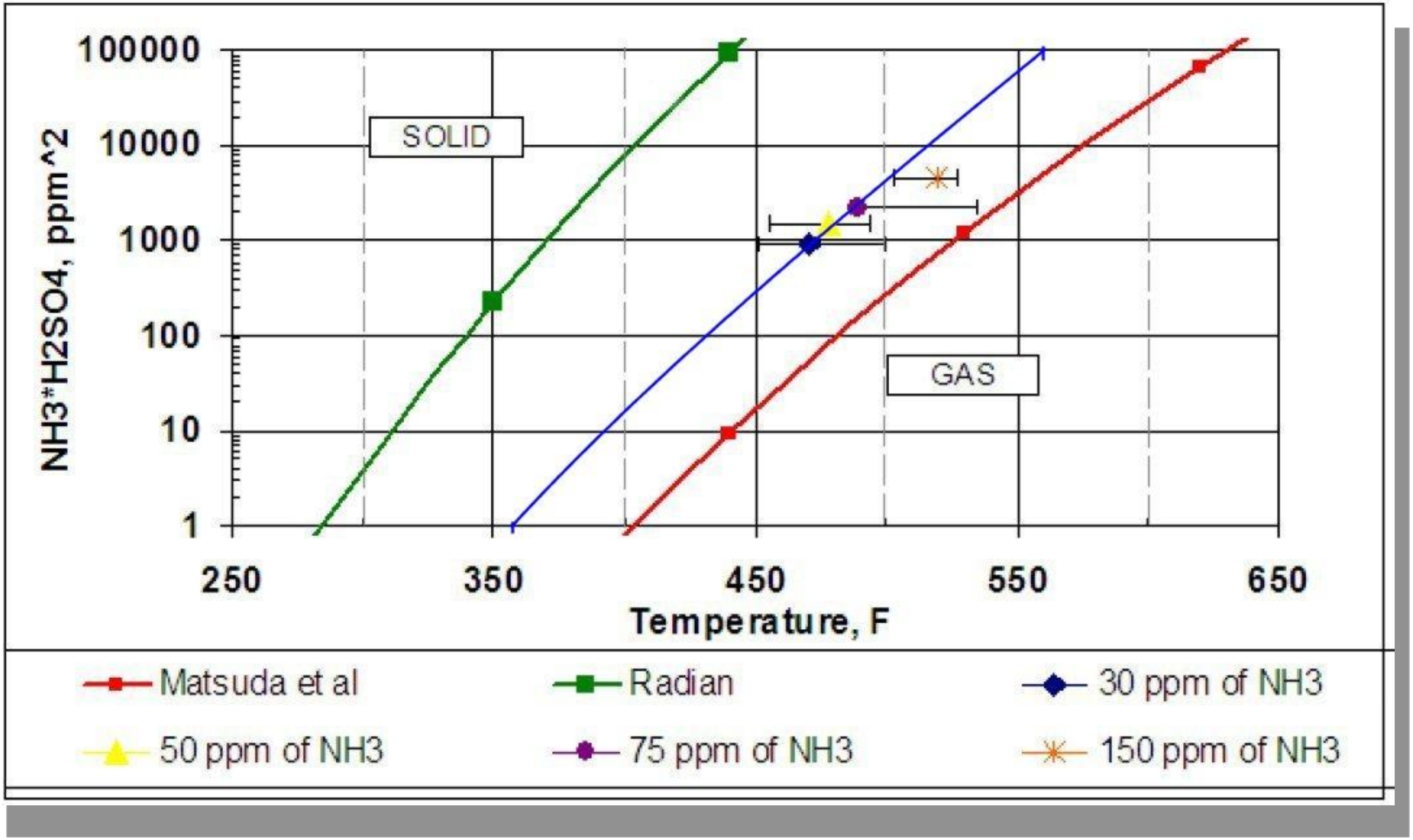




Ammonia Slip Results in ABS Deposits in the Air Heater

ABS Deposits Degrade Air Heater Efficiency and Affect Downstream Air Pollution Control Equipment

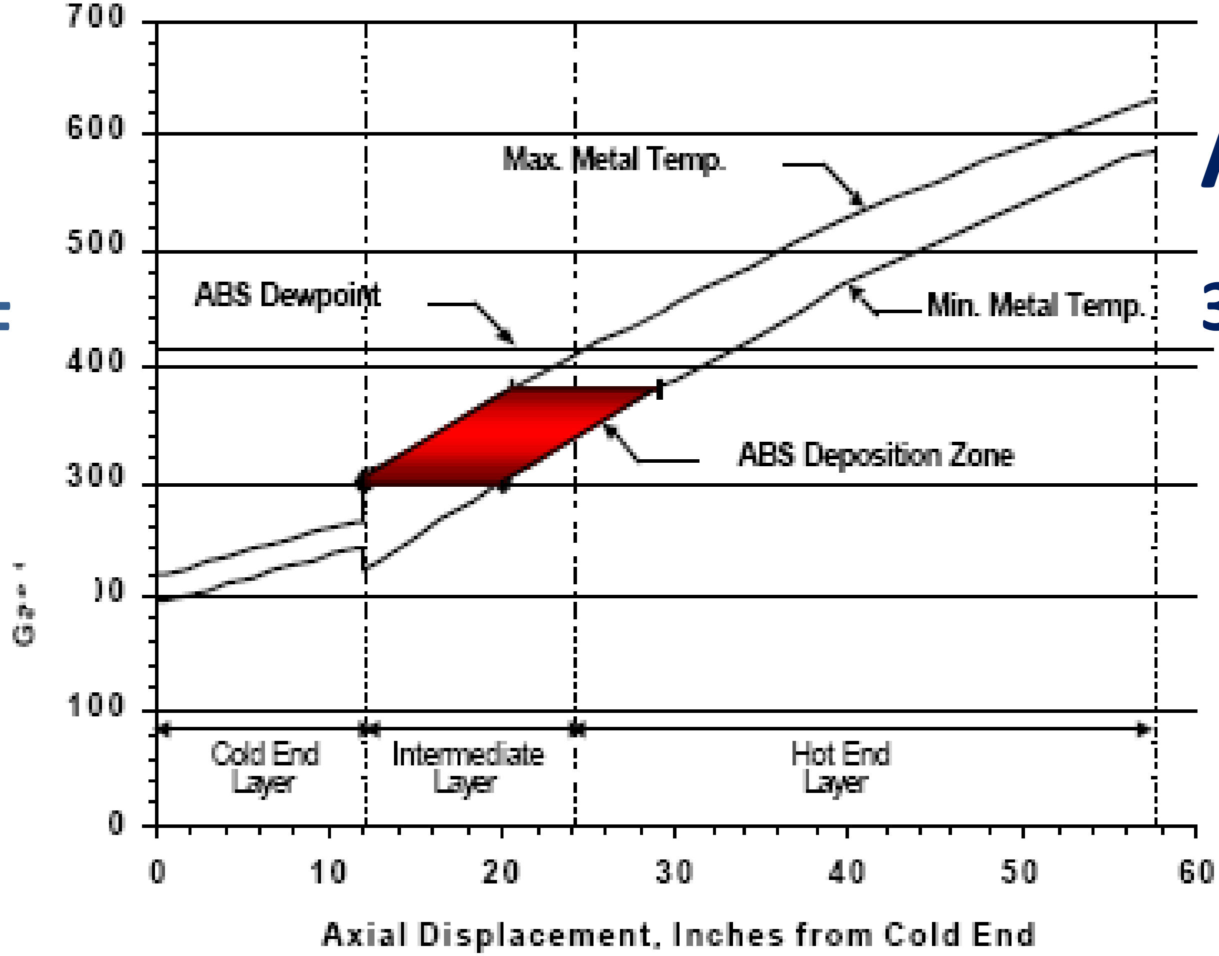
ABS Formation Temperatures



ABS Buildup at Precipitator Inlet

ABS Deposition Temperature

°F



ABS

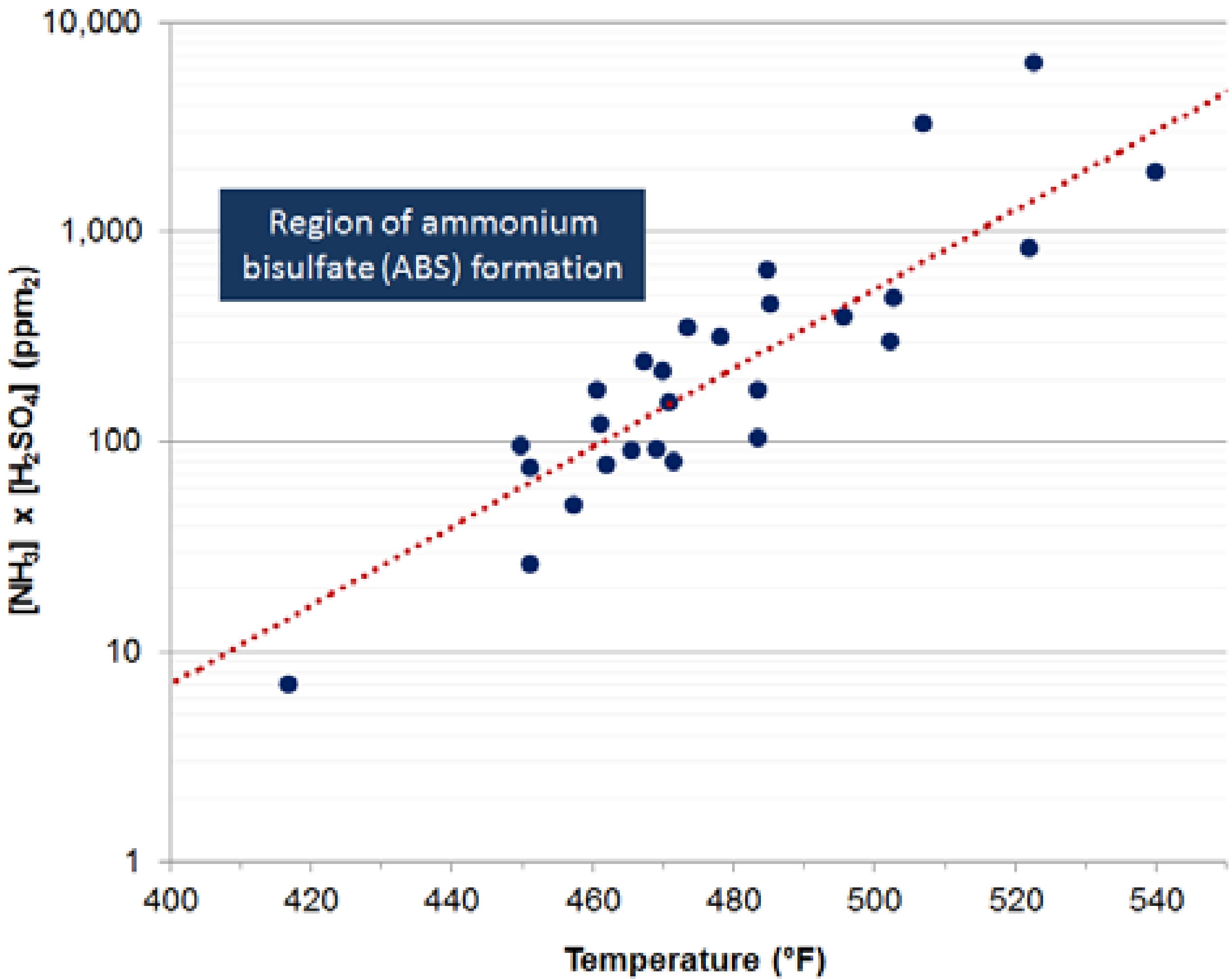
300°F TO 390°F

"Clean" Air Heater Cold End

ABS Prevention

Measure ABS Formation Temperature

ABS Formation Temperatures (Probe)



Breen Condensables System

- **Predict the Formation of ABS vs. AS**
- **Predict the Location where ABS will Deposit**
- **Adjust the Ammonia Feed**
- **Change Air Heater Metal Temperature**

Change Air Heater Metal Temperature

Bring ABS Deposits Closer to the Cold End

- Air Heater Bypass Duct
- Change Air Heater Rotational Speed
- Utilize Steam Coils

Must be Mindful of Downstream Limitations

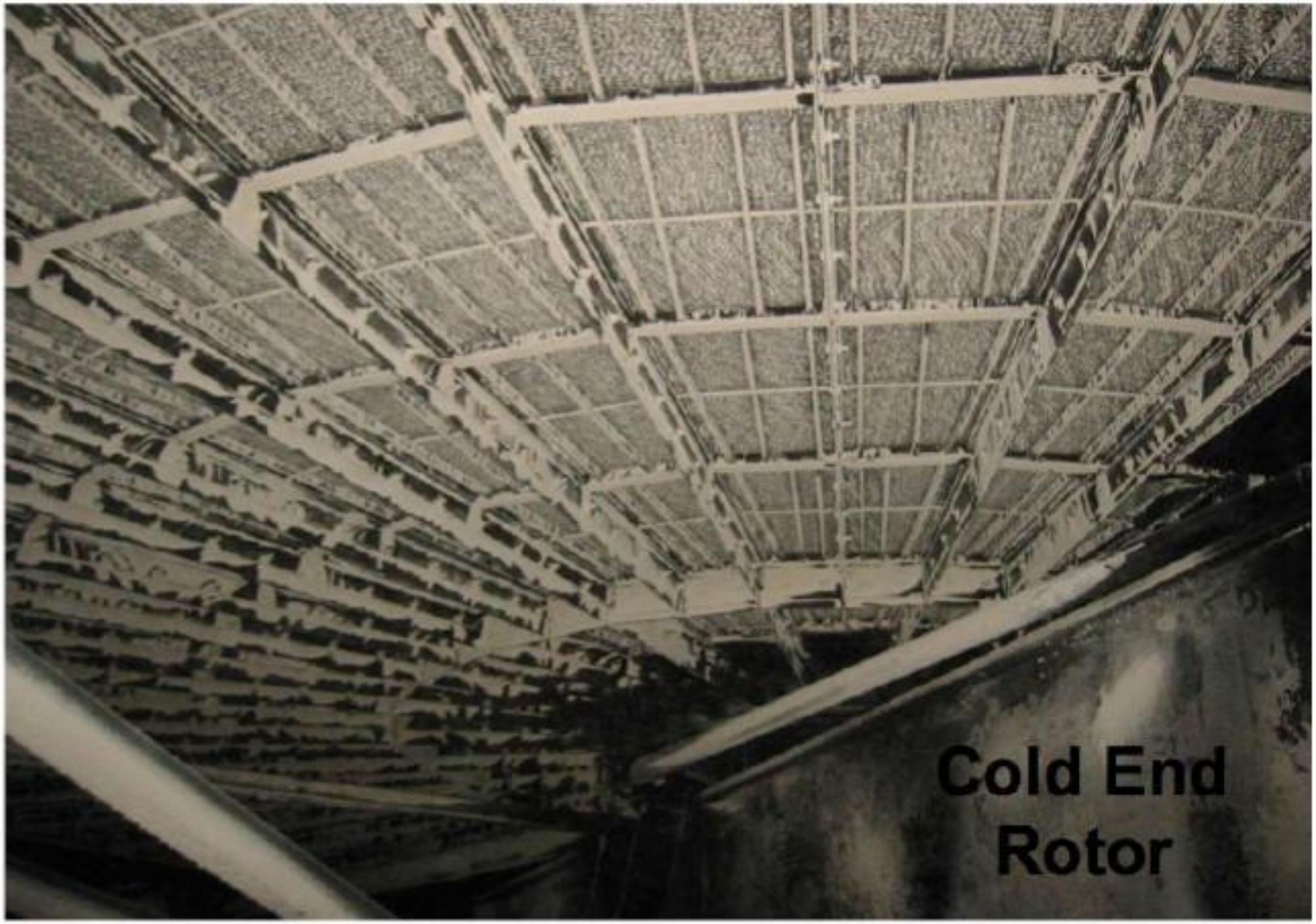
- – ESP Volume
- – ESP Resistivity
- – FF Bag Temperature

Breen Condensables System

- **Formation Temp: The temperature at which material will first form**
- **The Equilibrium Dew Point**
- **Evaporation Temp: The temperature at which material will self-evaporate**

AbSensor – AbS/SO3 System

Condensation Deposits



Soot Blowers - Typical

Dynamic Speed Control (DySC)

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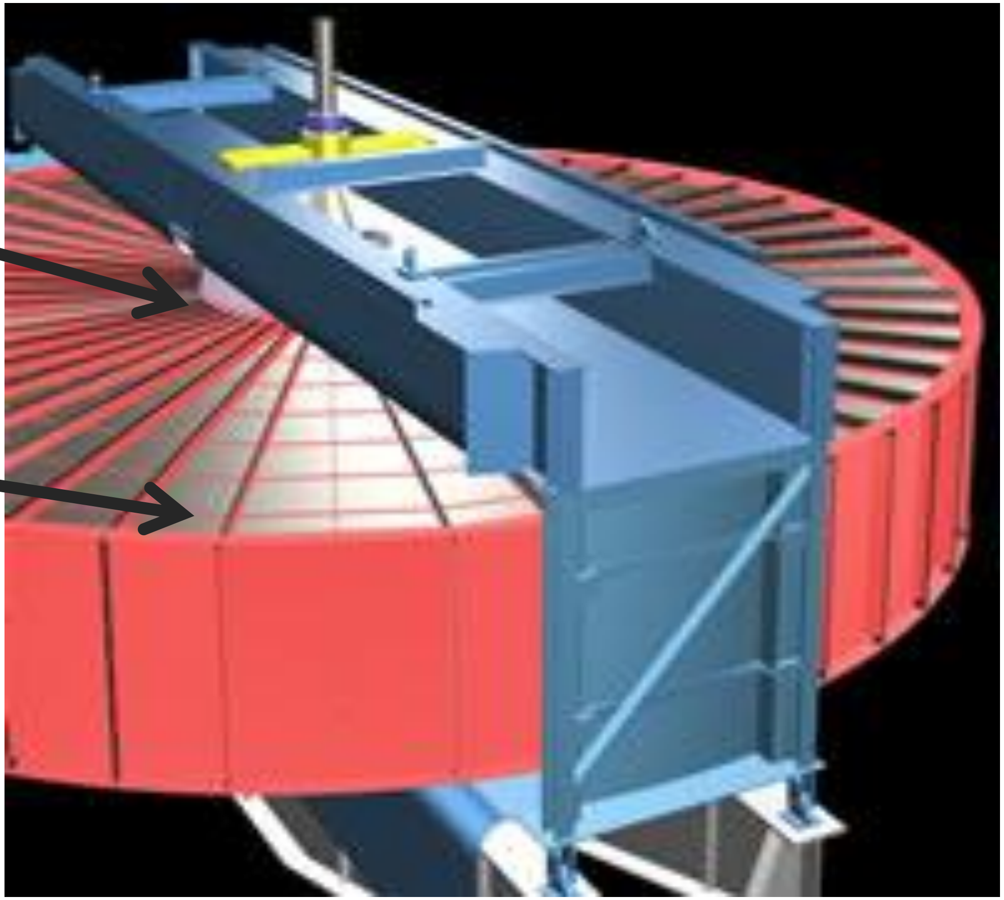
- Sootblower logic is modified to allow the nozzle to be positioned as desired, and then left stationary
- The Rotor Speed Coordinated With Nozzle Position To Provide Suitable Residence Time.

Penetration vs. Angular Velocity

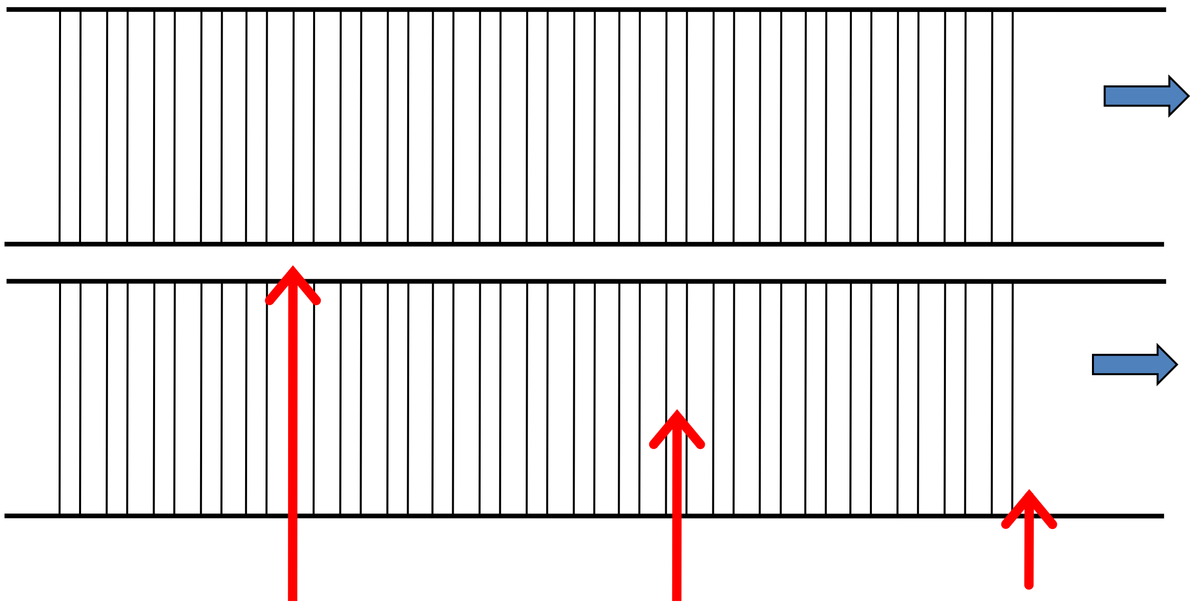
Penetration Depth is greater here:

Than it is here:

Due to significant differences in angular velocity



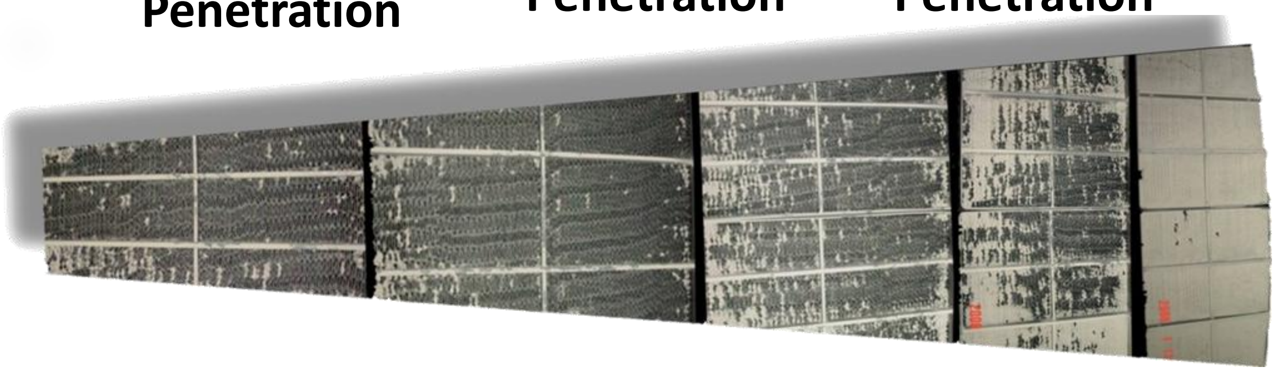
Soot Blower Penetration vs. Tangential Velocity



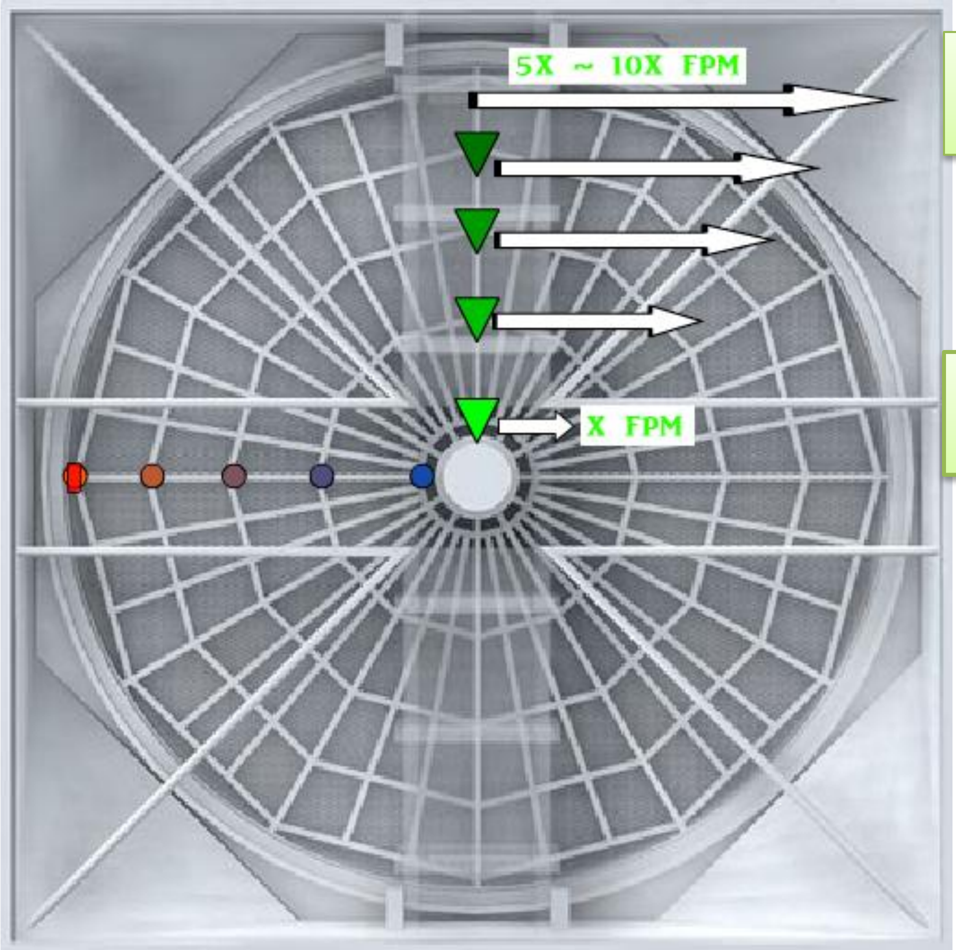
Slow Speed, Full Penetration

Medium Speed, Partial Penetration

High Speed, Reduced Penetration



Angular Velocity/Sootblowing



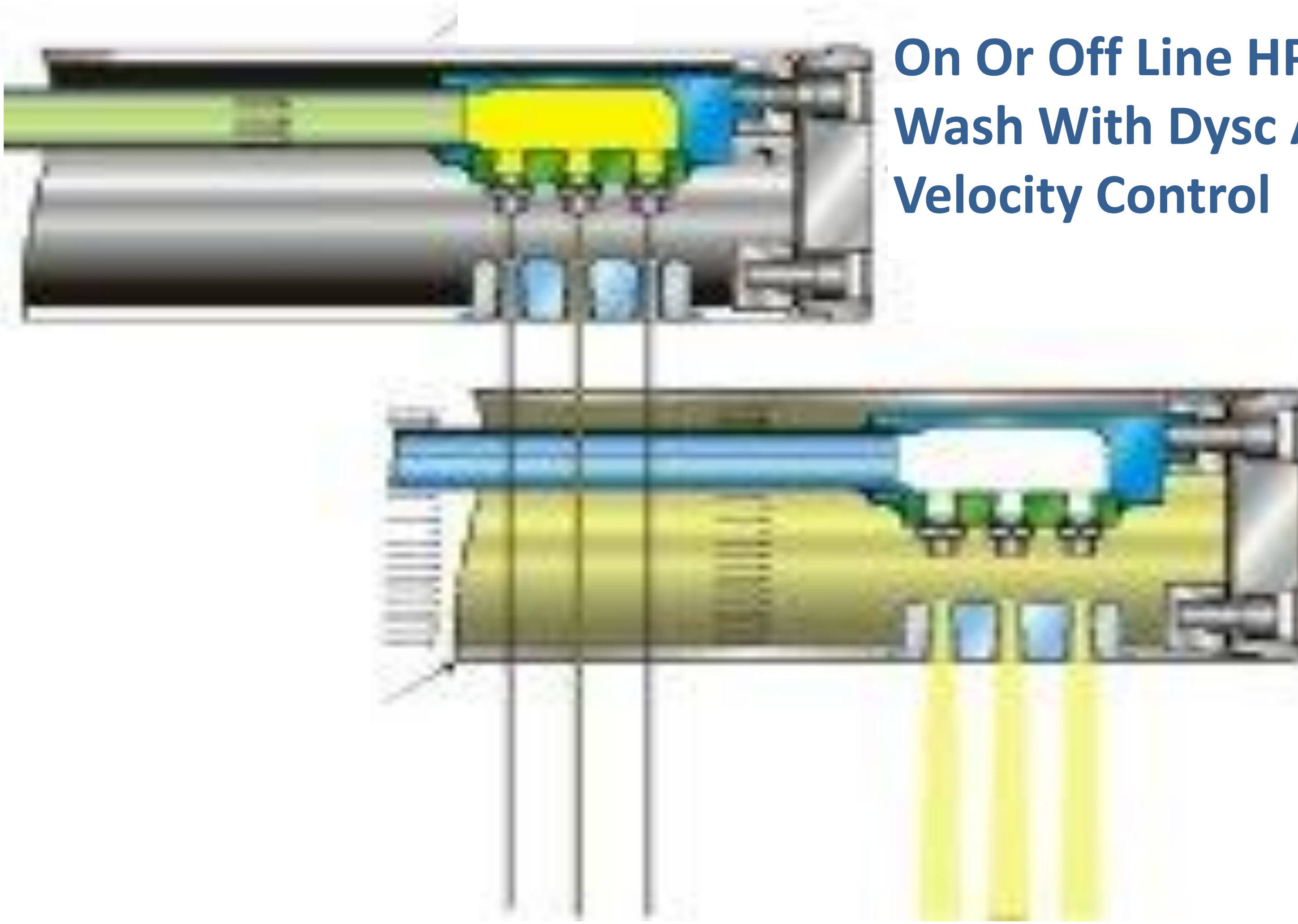
Outer = 75-150 ft/min

Inner = 15 ft/min

Perimeter Angular Velocity Increases up to 10x

Dual Media Blower

Dual Media Blower



On Or Off Line HP Water Wash With Dysc Angular Velocity Control

Bromine for Hg Oxidation

- Br_2 and/or HBr (Hydrogen Bromide)
- b.p. Br_2 = 137F   HBr = - 88F
  - Oxidizes Mercury
  - Oxidizes Iron at 300 F+
- HBr + H_2O = Hydrobromic Acid (b.p. 280 F)
- Hydrobromic acid is stronger than HCl

BROMINE PAC PROBLEM?

RAPID CORROSION OF AIR HEATER ELEMENT

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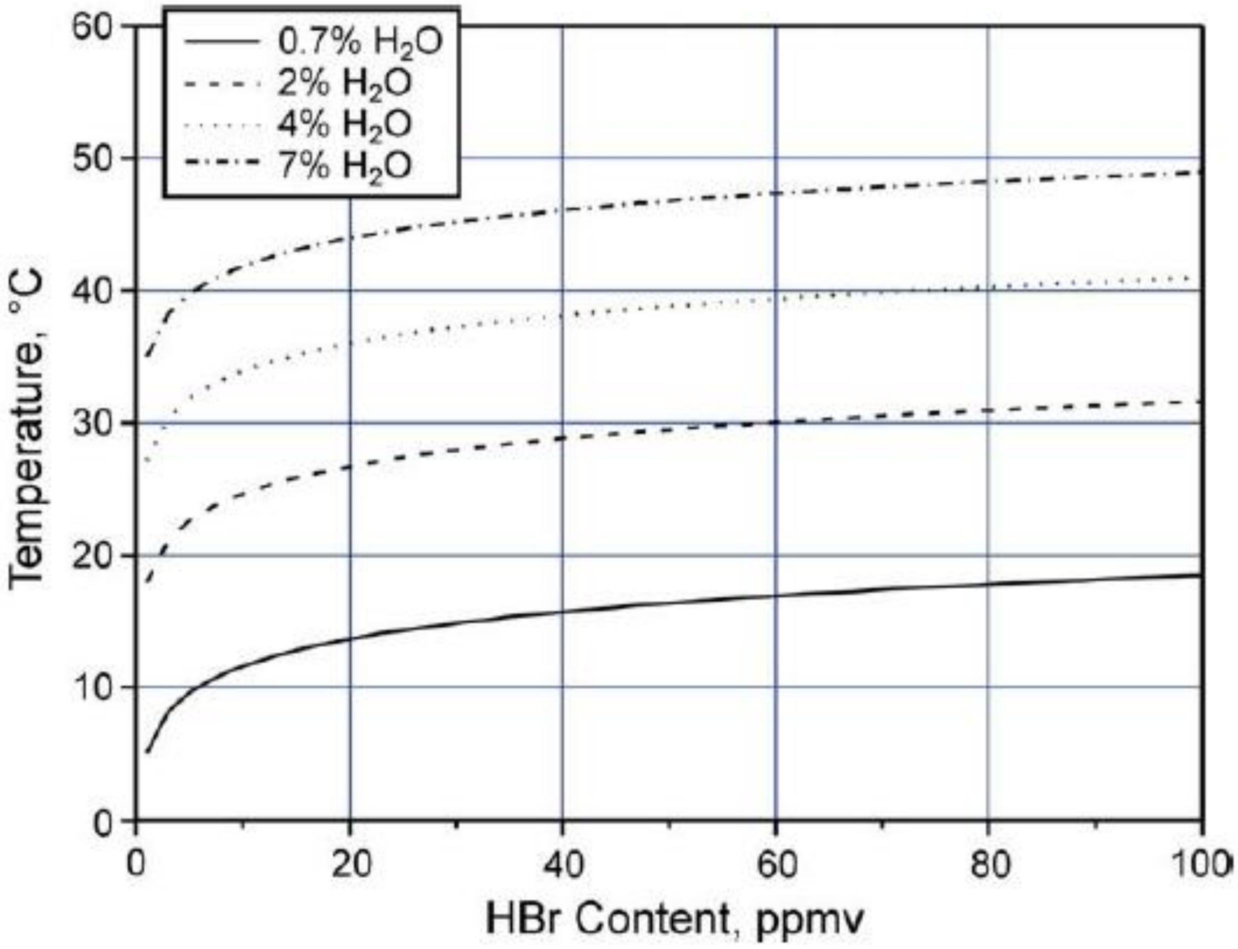
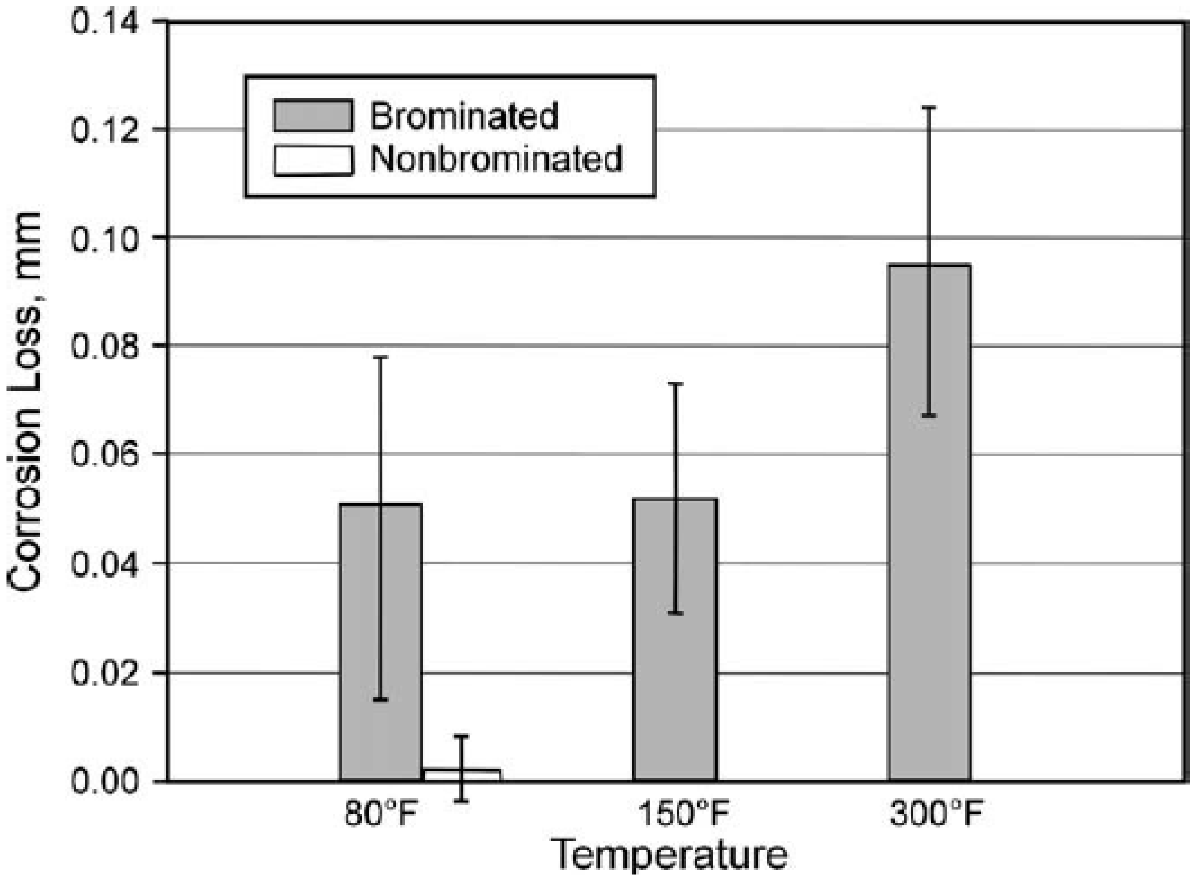
HYDROBROMIC ACID (HBr) DEWPOINT



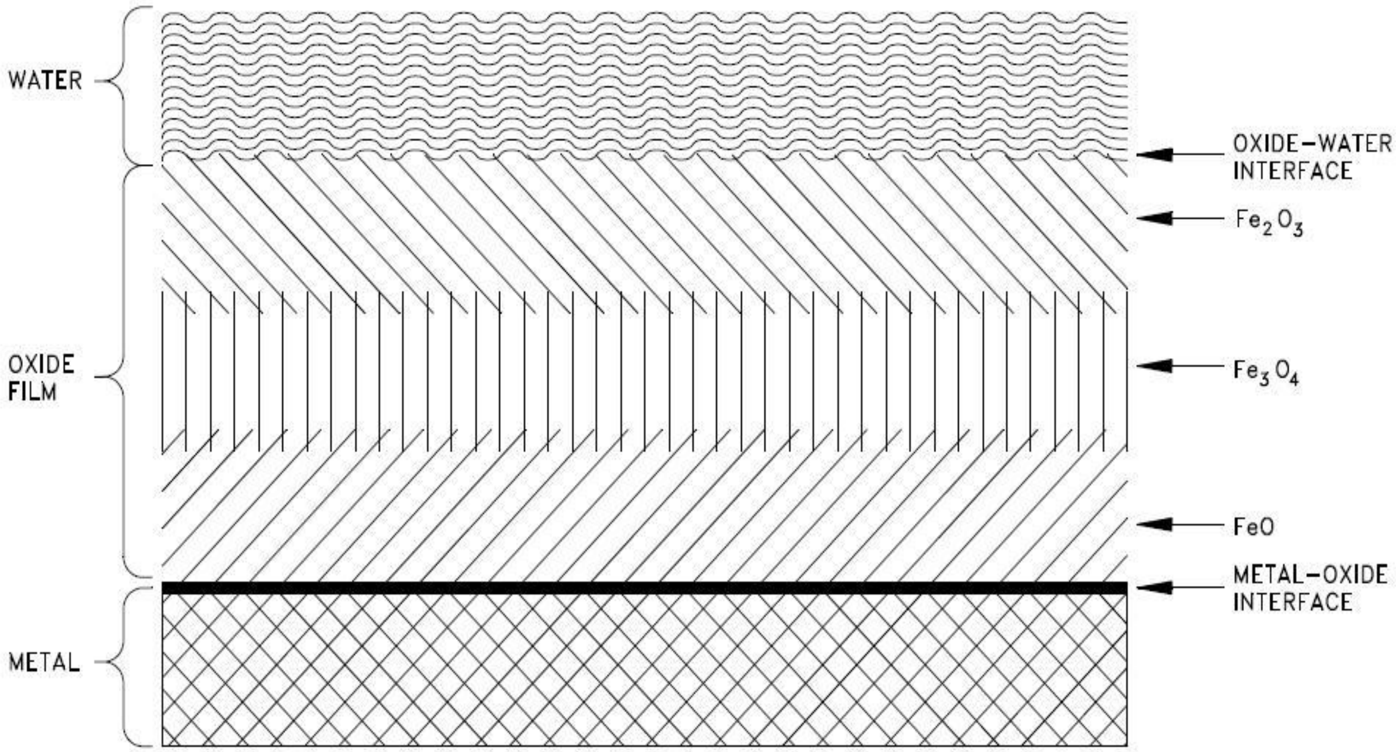
EERC

Br_2 GAS PHASE OXIDATION



EERC

PROTECTIVE OXIDE LAYER



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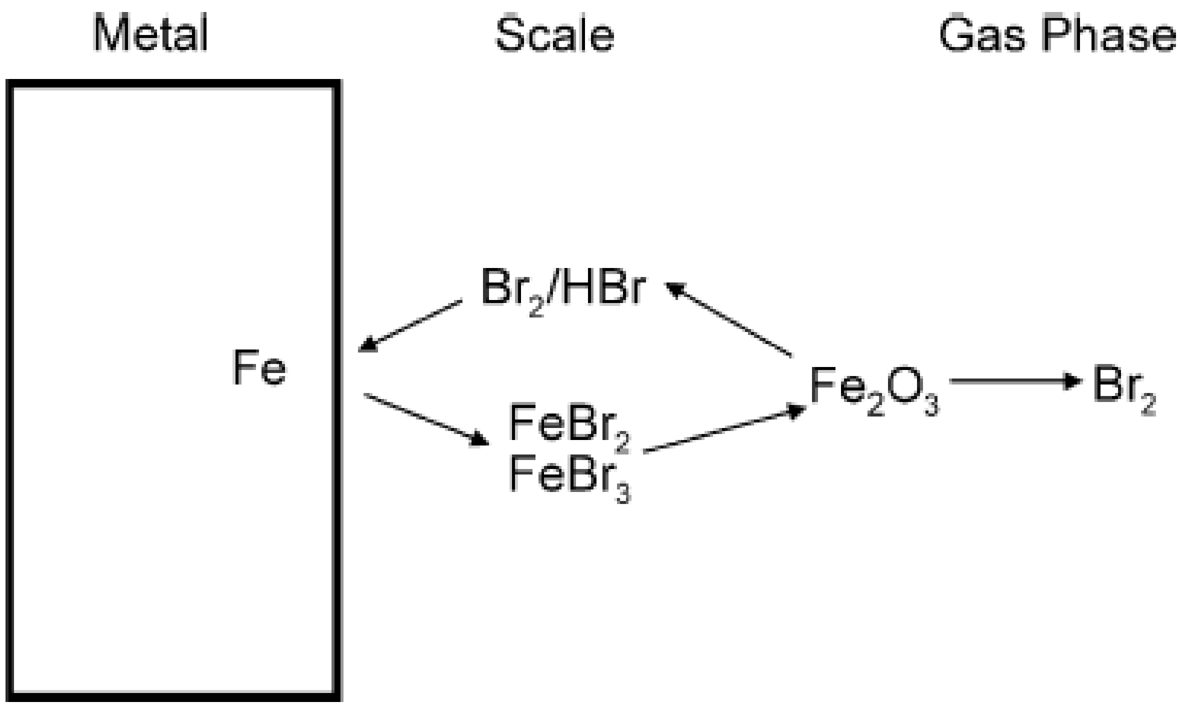
BR_2 GAS PHASE OXIDATION



EERC

BROMINE PAC PROBLEM?

RAPID CORROSION OF AIR HEATER ELEMENT

EFFECTS OF SO_3 and ABS on AIR HEATER PERFORMANCE

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