REINHOLD ENVIRONMENTAL Ltd.

2012 NOx-Combustion Round Table & Expo Presentation

February 13-14, 2012, in Columbus, OH / Hosted by AEP

2012 NO_X – Combustion/PCUG Conference

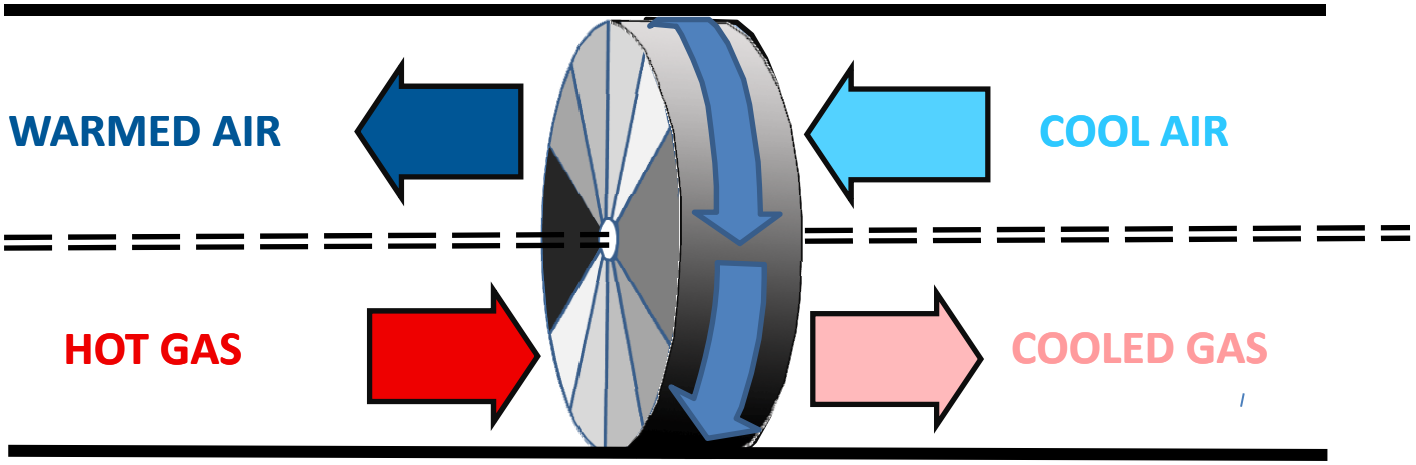
SCRs and Air Heater Problems

Causes, Prevention, and Cures

John Guffre, P.E.
Paragon Air Heater Technologies

Function of an Air Heater

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

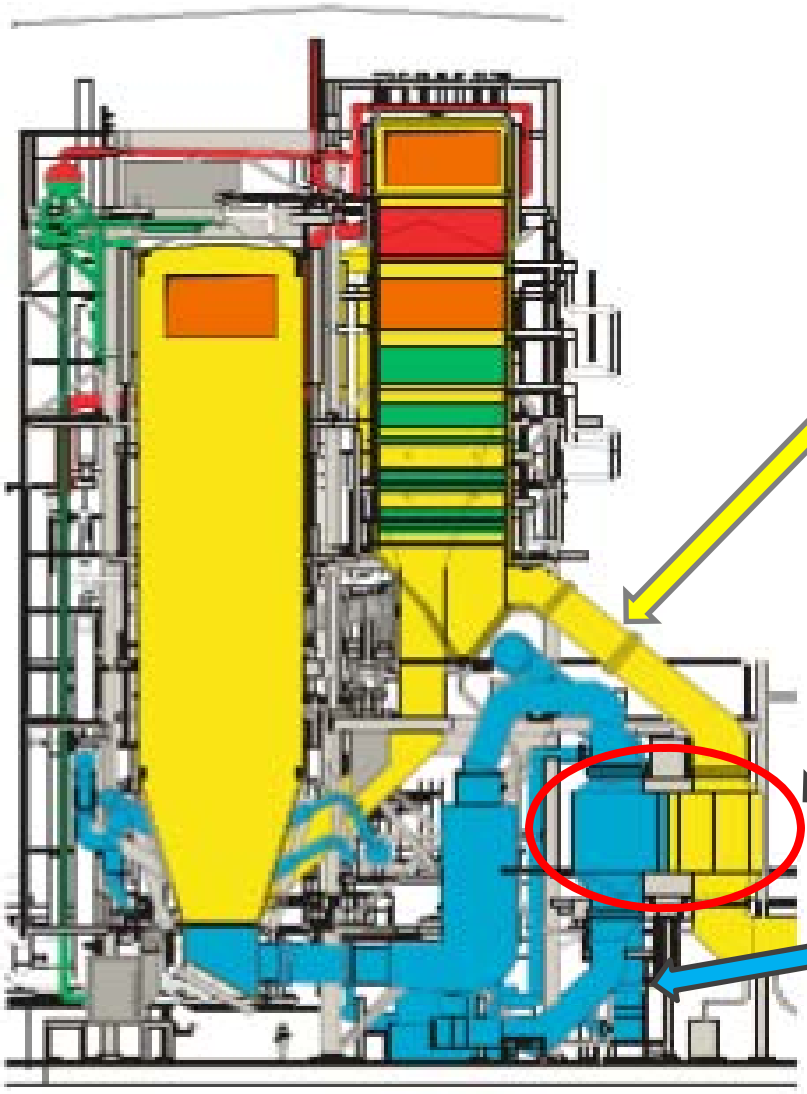


Benefits of an Air Heater

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

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

Air And Gas Flow From Air Heater



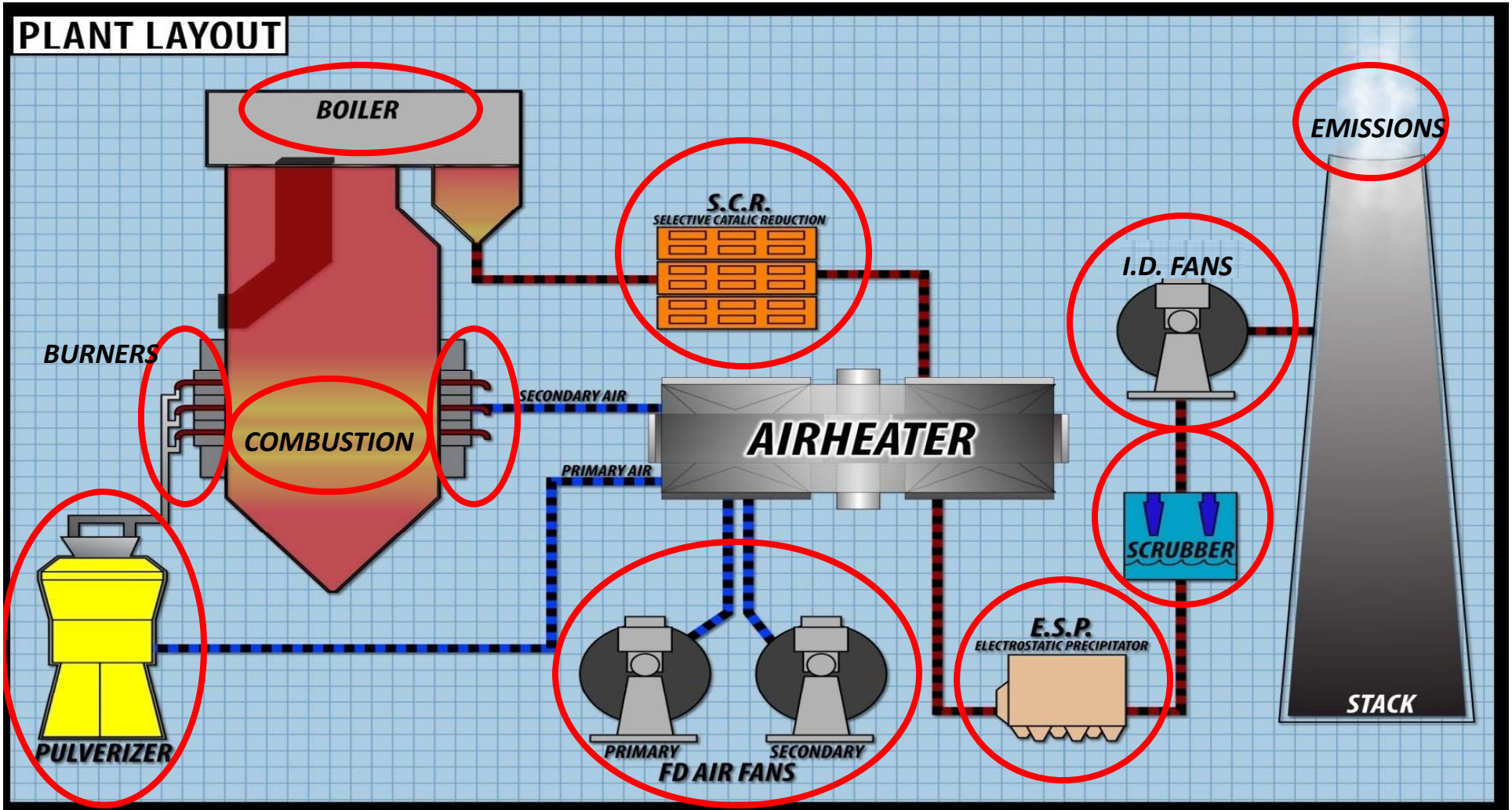
HOT FLUE GAS TO AIR HEATER

AIR HEATER

WARMED AIR TO BOILER

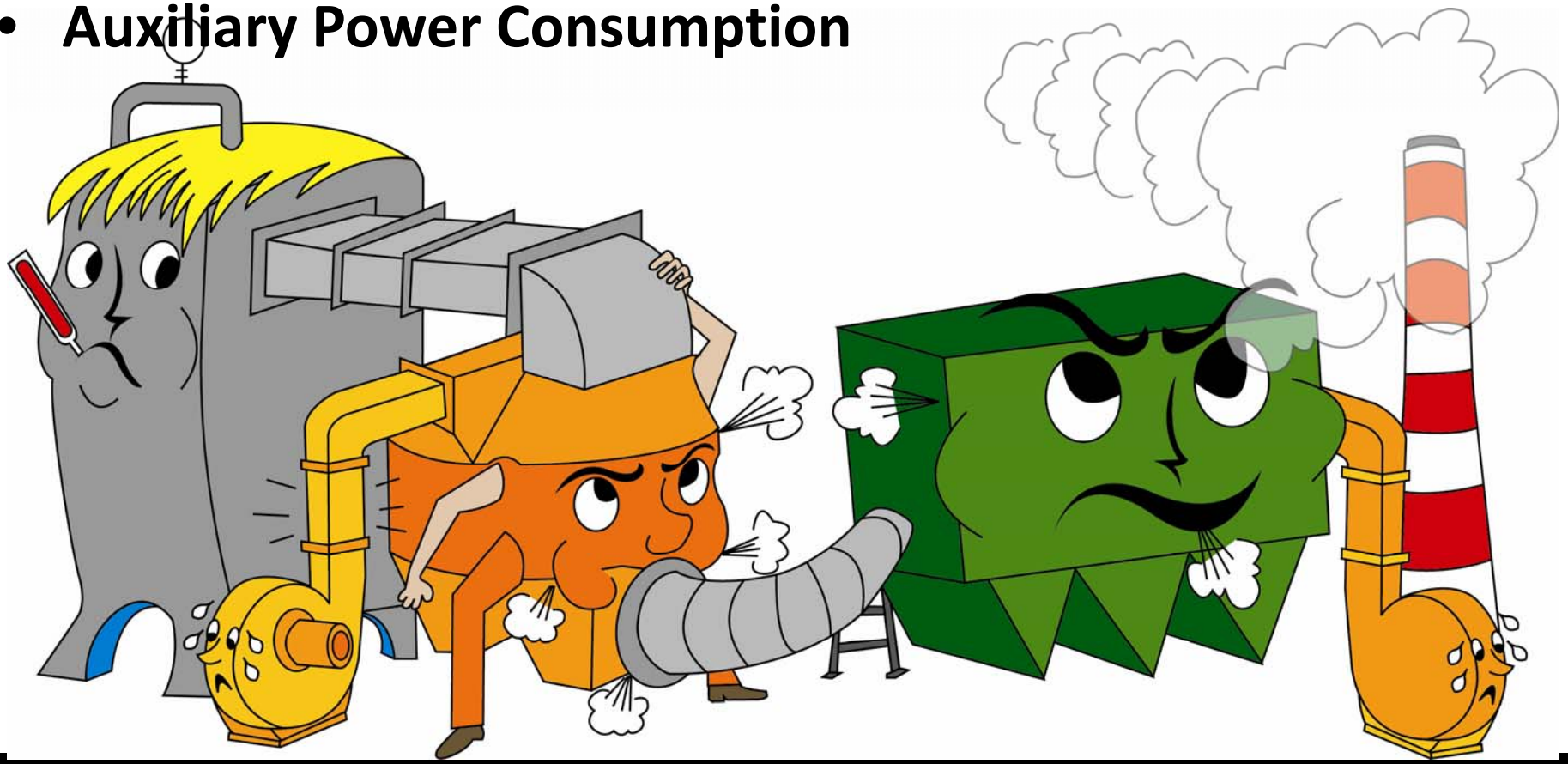
The SCR Impacts the Air Heater

The Air Heater Impacts Combustion and APC Equipment

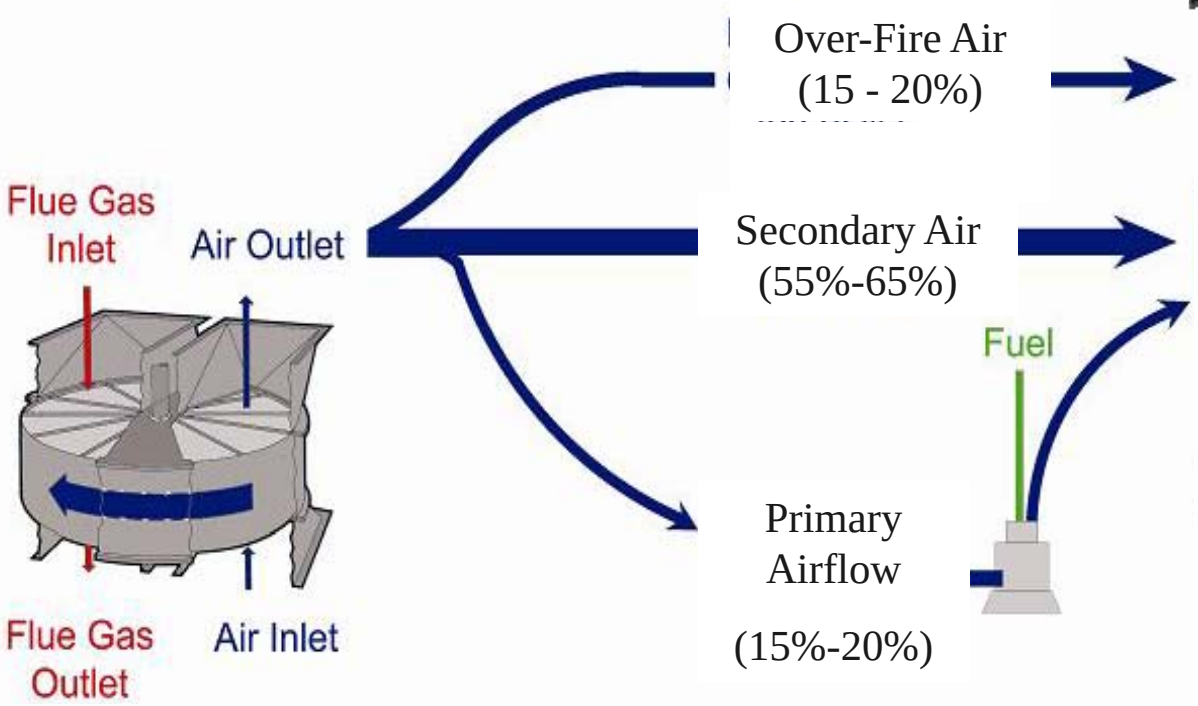


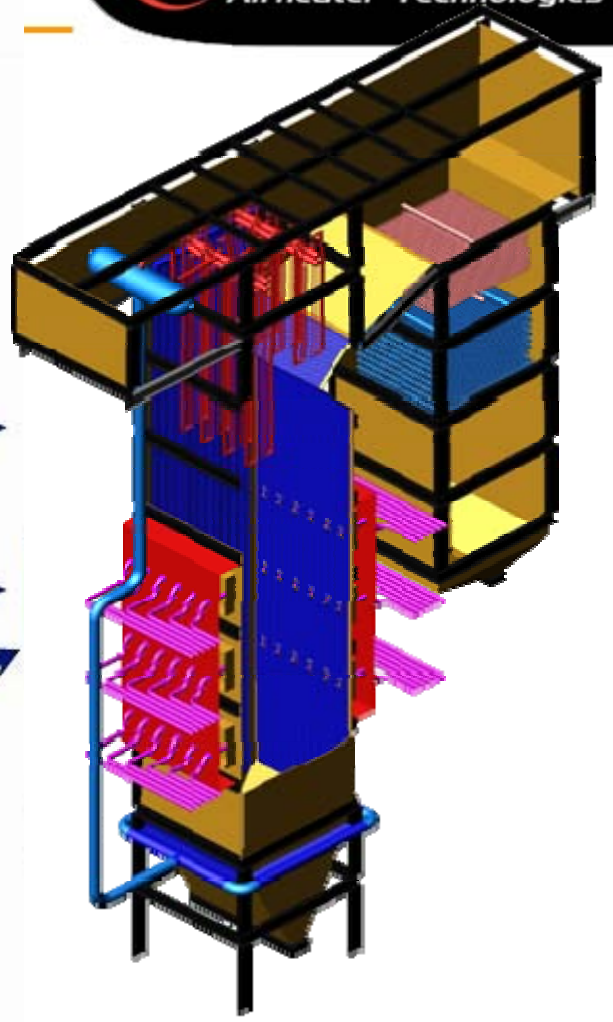
Inter-Relationships

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

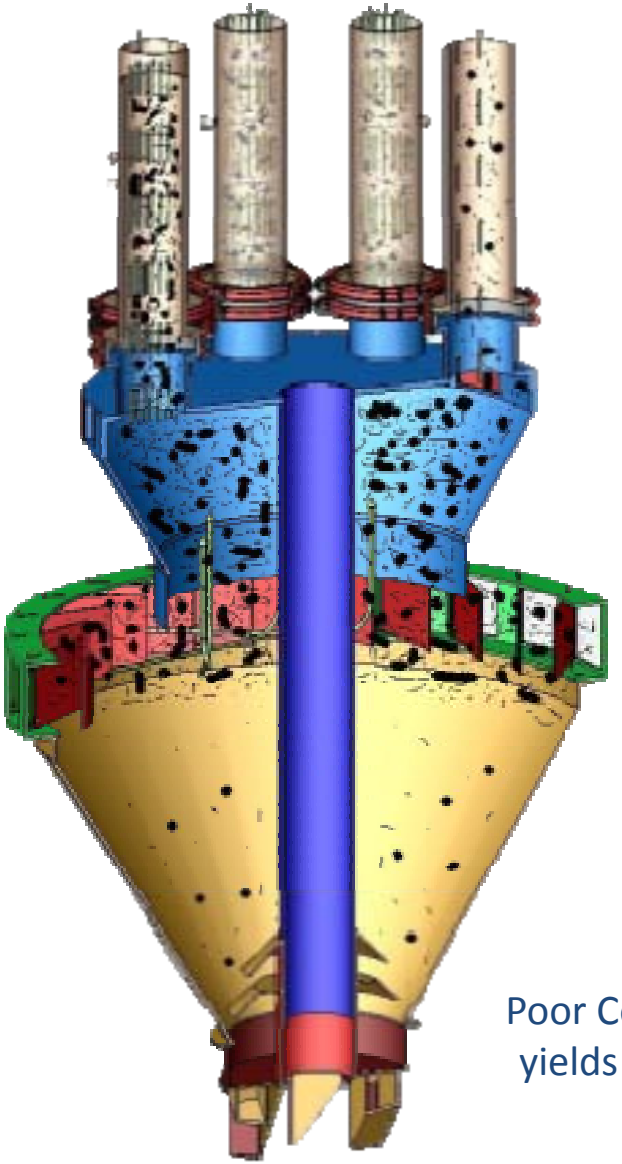


Combustion Airflow Distribution & Control

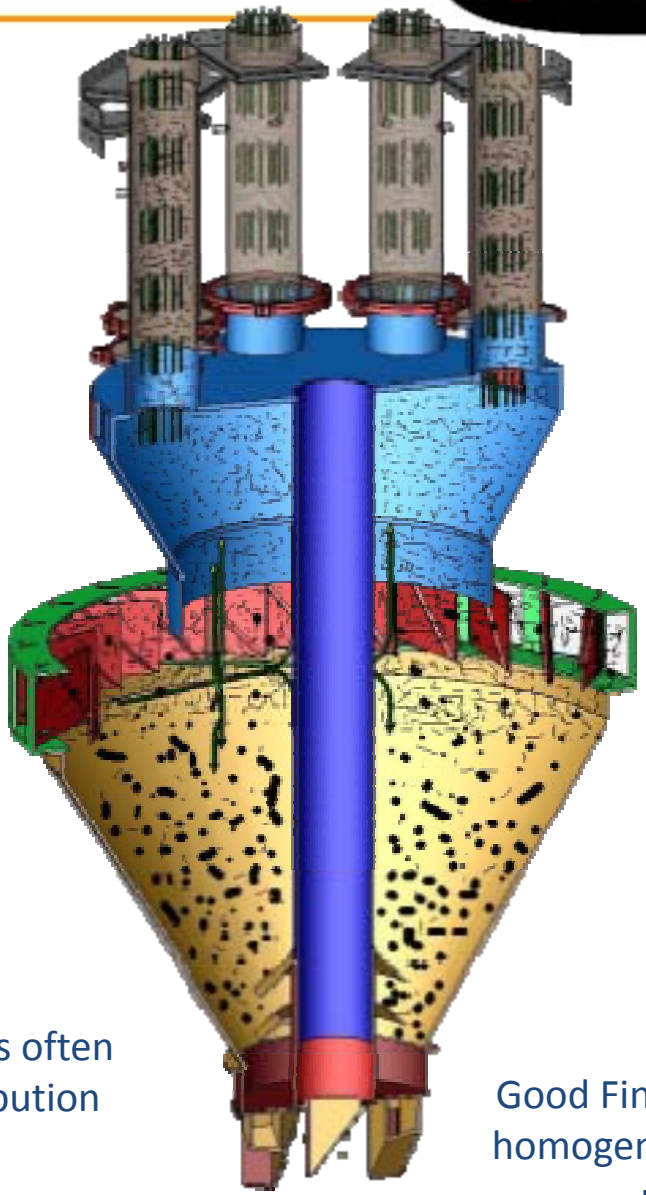




Coal Fineness



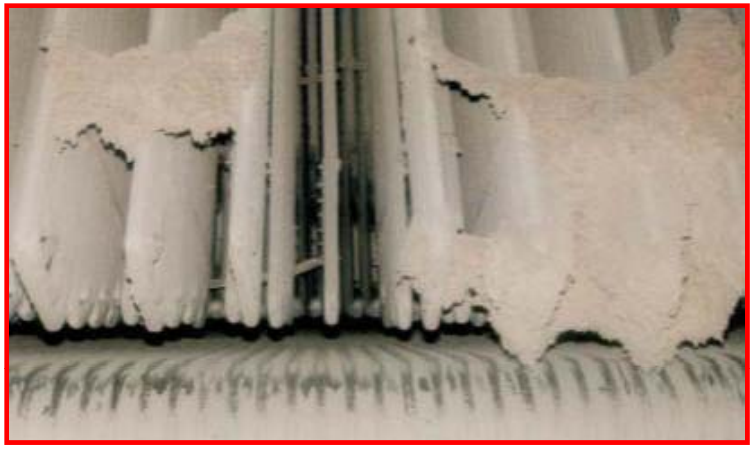
Poor Coal Fineness often yields poor distribution



Good Fineness Creates a homogenous & balanced mixture

Catalyst Fouling

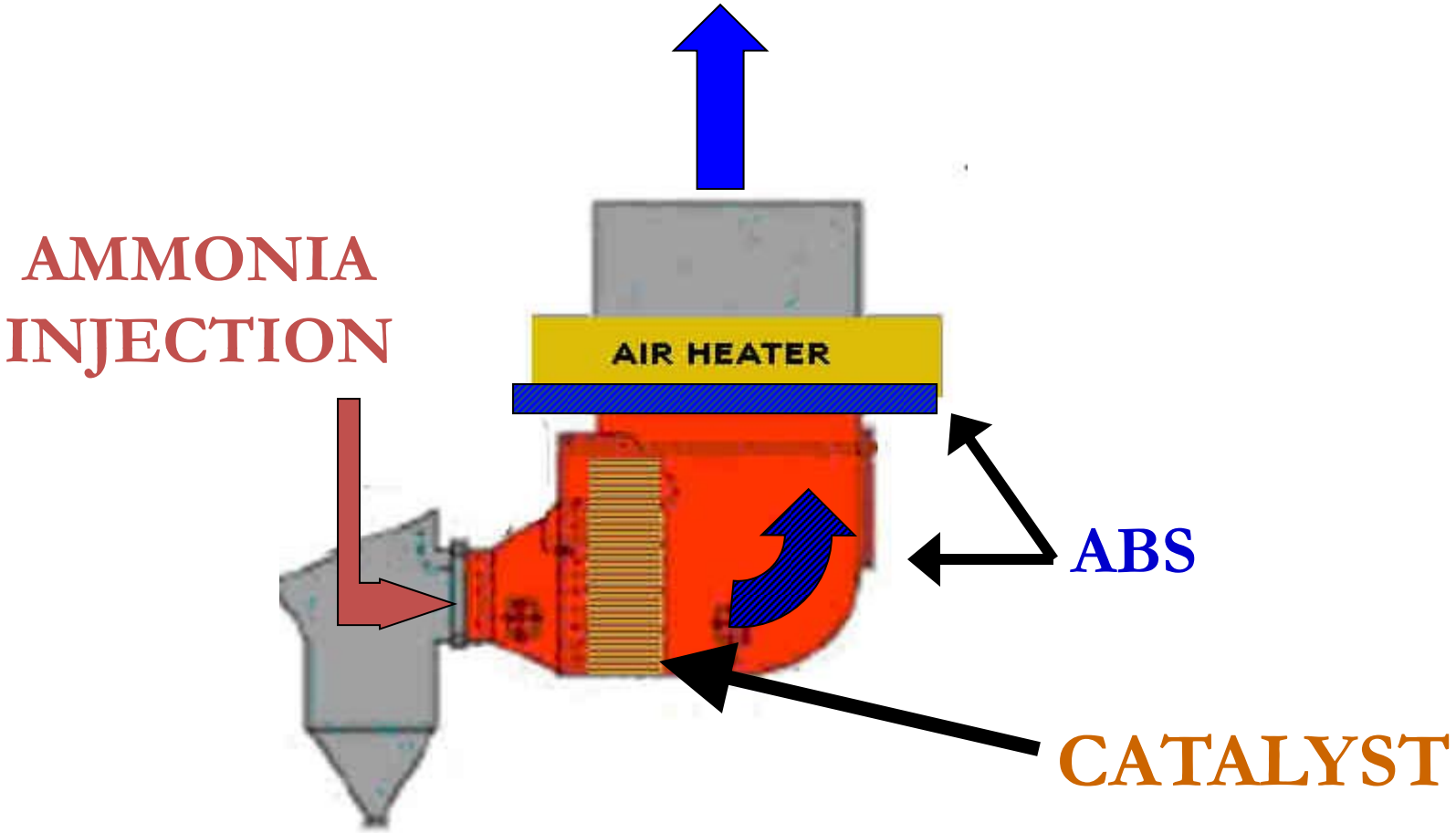
1. Low Primary Air Temp or Flow
2. Open Mill Classifiers
3. Increase Coal Particle Size
4. Fireball Moves Upward
5. Increased FEGT
6. Popcorn Ash is Formed
7. Catalyst Fouls
8. NH3 Slip Increases
9. AH Fouls
10. Go to Step 1 - Repeat



ABS

ABS FOULING AND CORROSION

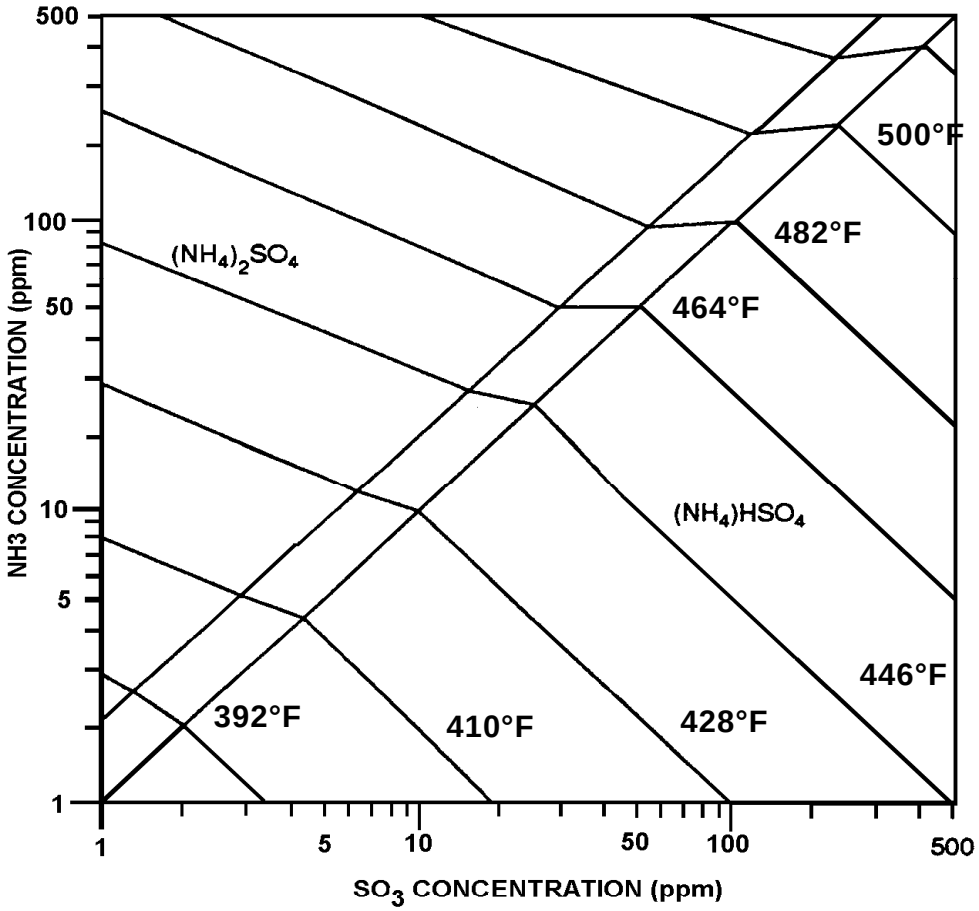
SCR in Relation to Air Heater



Formation of Ammonium Bisulfate

$$NH_3 + SO_3 + H_2O = NH_4HSO_4$$

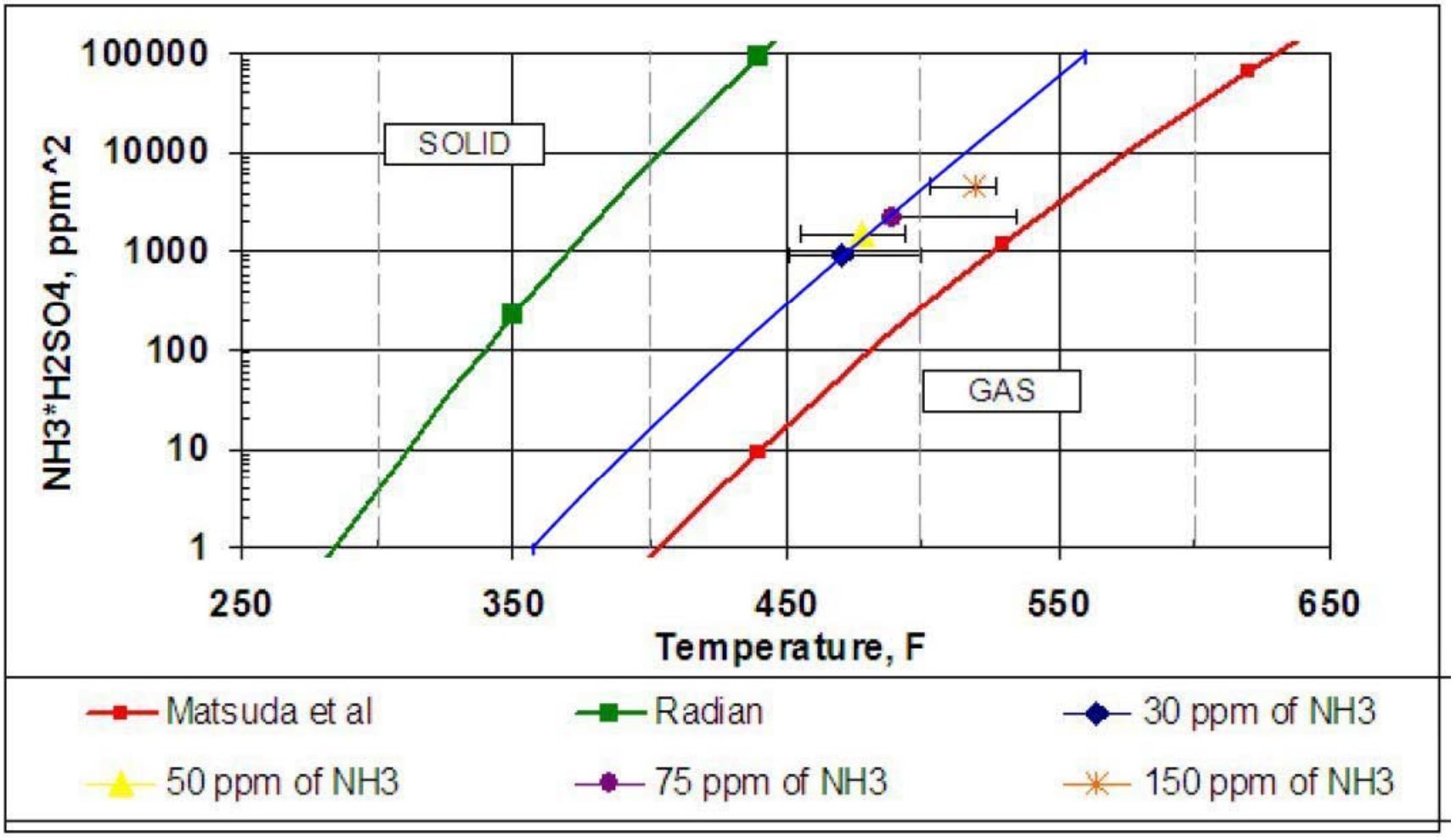
Hitachi Zosen Ammonium Sulfate and Bisulfate



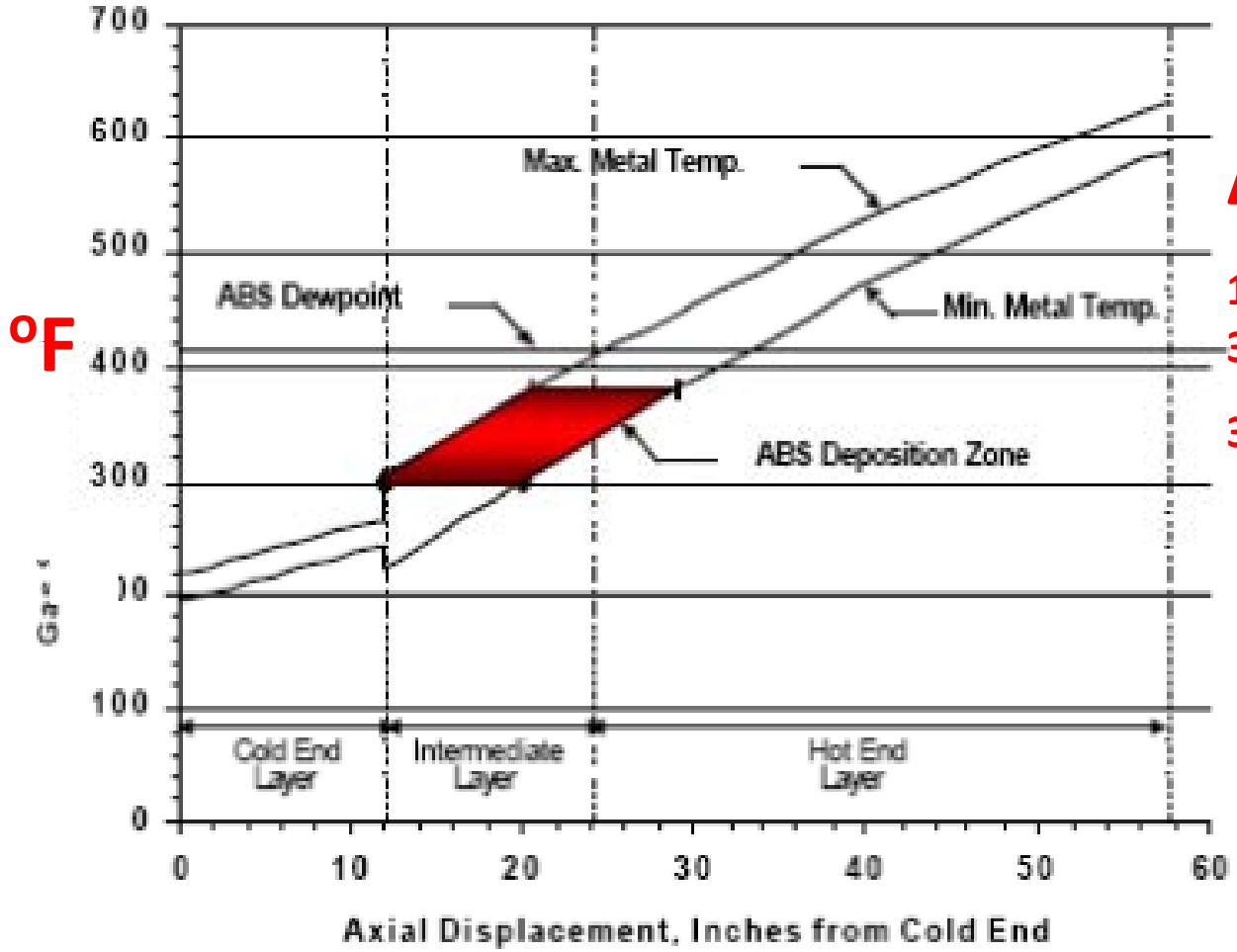
$(NH_4)_2SO_4$ = Ammonium Sulfate

$(NH_4)HSO_4$ = Ammonium Bisulfate

ABS Formation Temperatures



ABS Deposition Temperature



ABS

12 INCHES TO 30 INCHES

300°F TO390°F

ABS

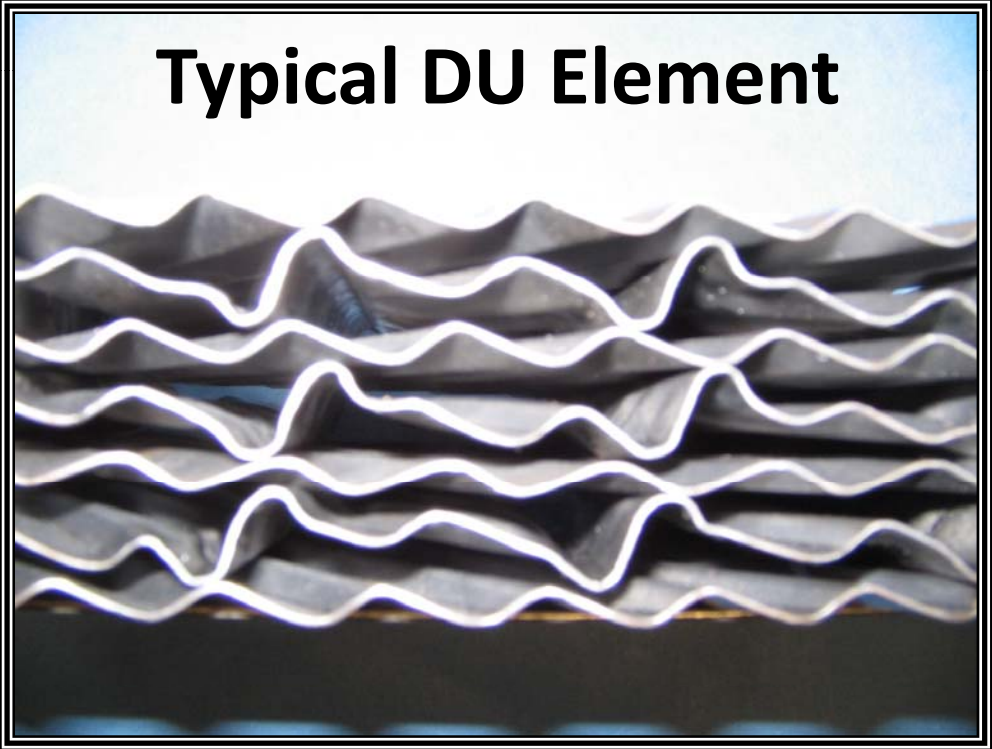
FOULING AND CORROSION

ABS Buildup at Precipitator Inlet

Heat Transfer Element

- **Turbulent Flow Accelerates Heat Transfer**
- **Turbulence Promotes ABS Deposition**

Typical DU Element



Ammonium Bisulfate

ABS Liquid Accumulates on Element

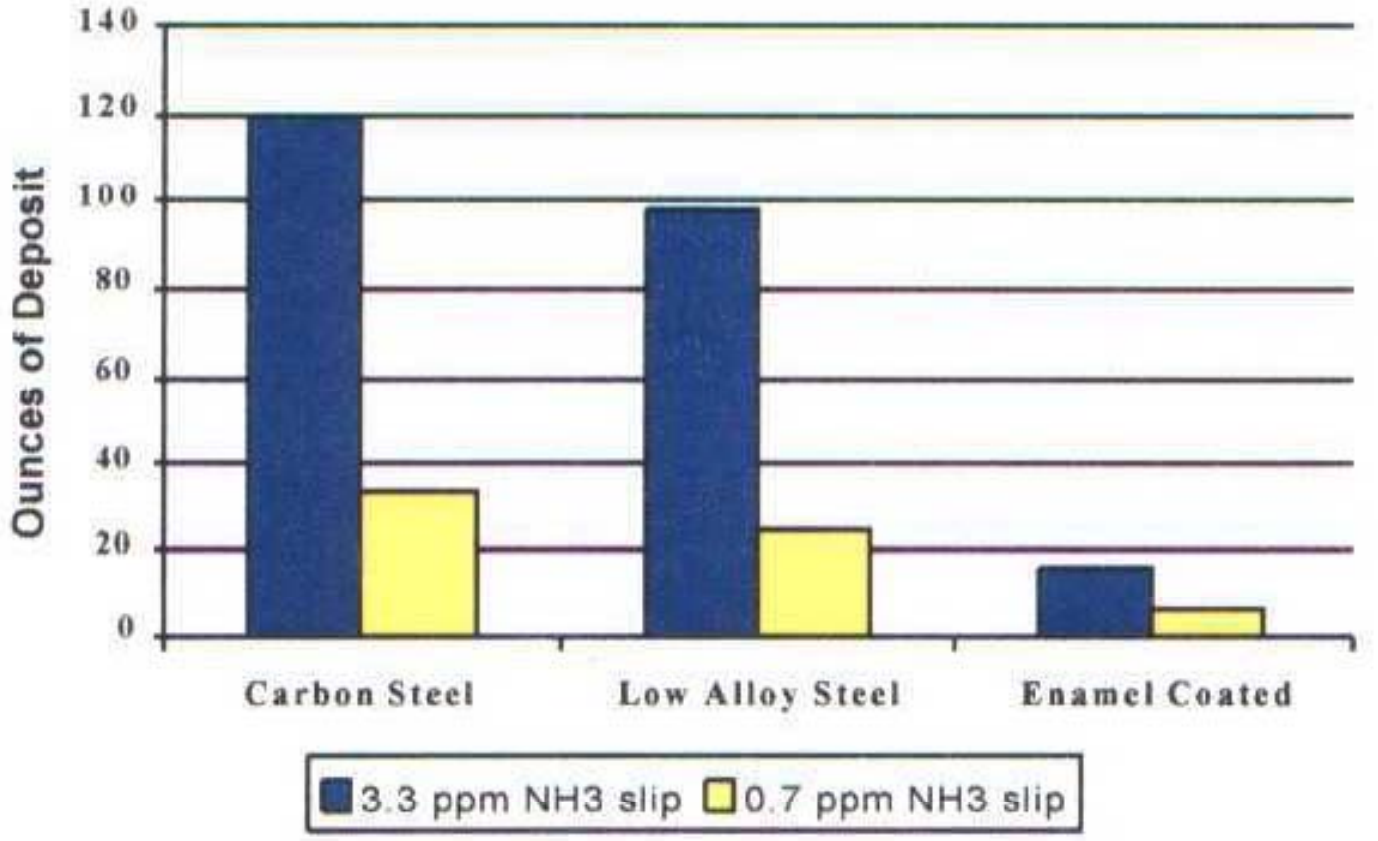
- Temperature
- Turbulent Impact
- Smooth Surfaces Reduce Deposition

ABS Deposits Are Corrosive

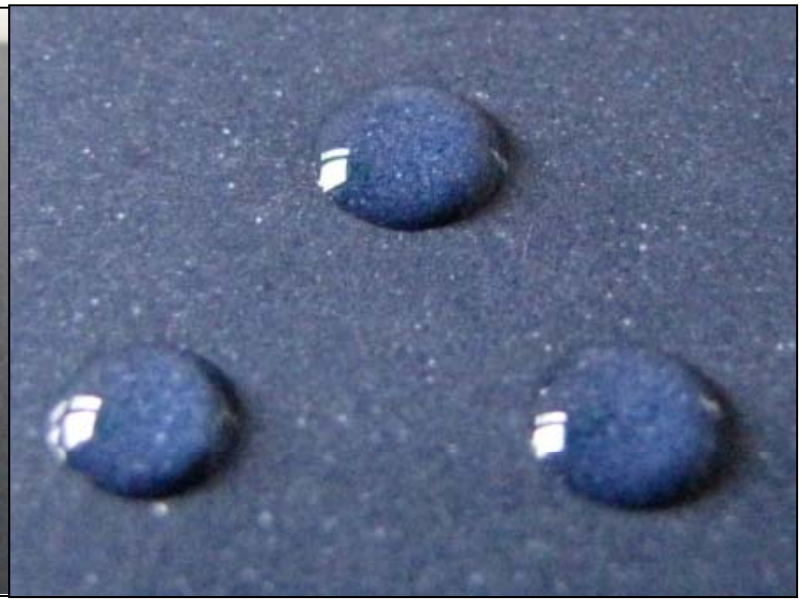
ABS combined with Flyash is adherent

Oxidized Surfaces increase ABS adhesion

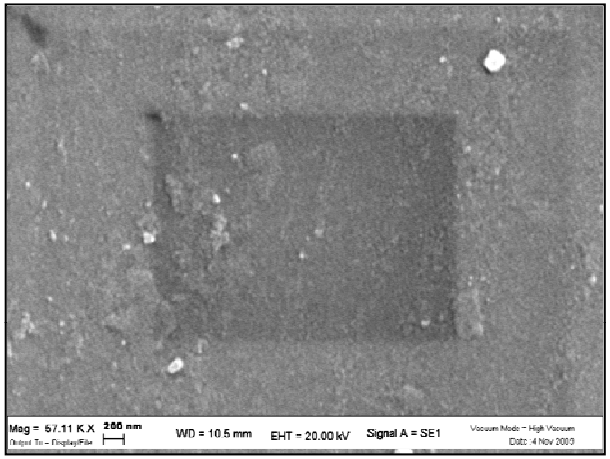
Texture and ABS Deposits



Non-Stick

Standard enamel	A "Non- Stick" enamel
	

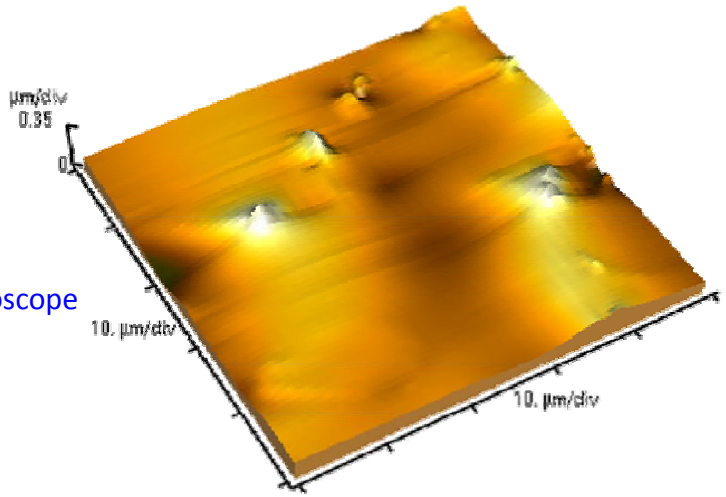
Standard Enamel Surface

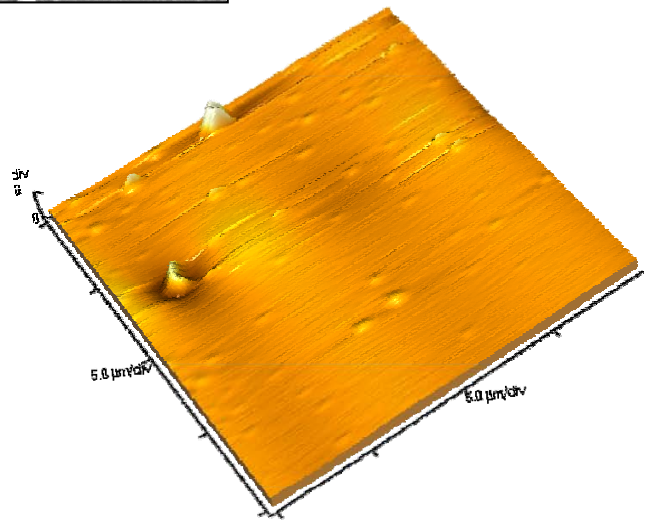


Standard enamel surface quality

Scanning Electron Microscope (SEM) analysis

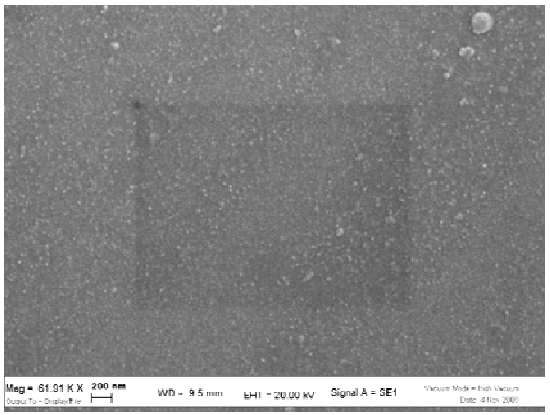
Atomic Force Microscope (AFM) analysis



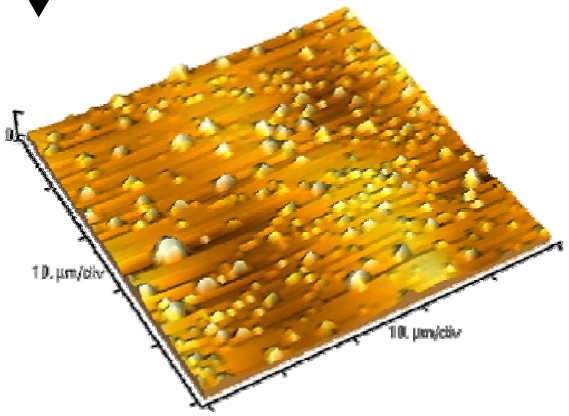


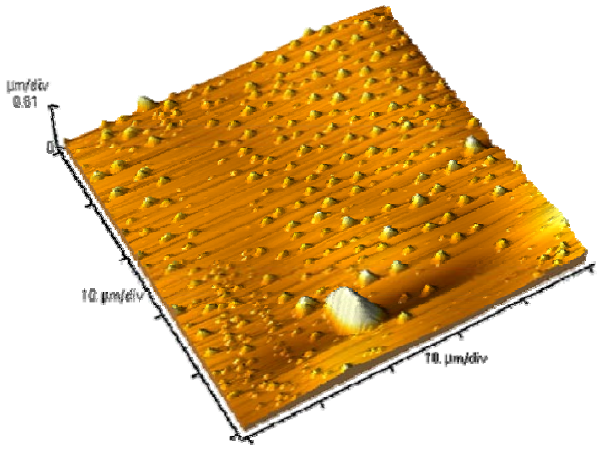
“Non-Stick” enamel

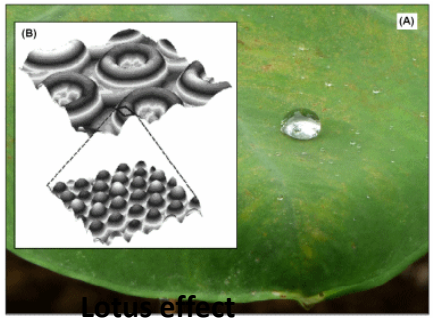
"Non Stick" enamel surface quality



Scanning Electron Microscope (SEM) analysis







Lotus Effect

Ash and ABS Deposits

Direct Effects

- **Pressure Drop**
- **Airheater Efficiency**
- **Increased Gas Outlet Temp. (Heat Rate)**
- **Outages for AH Washing**

Ash and ABS Deposits

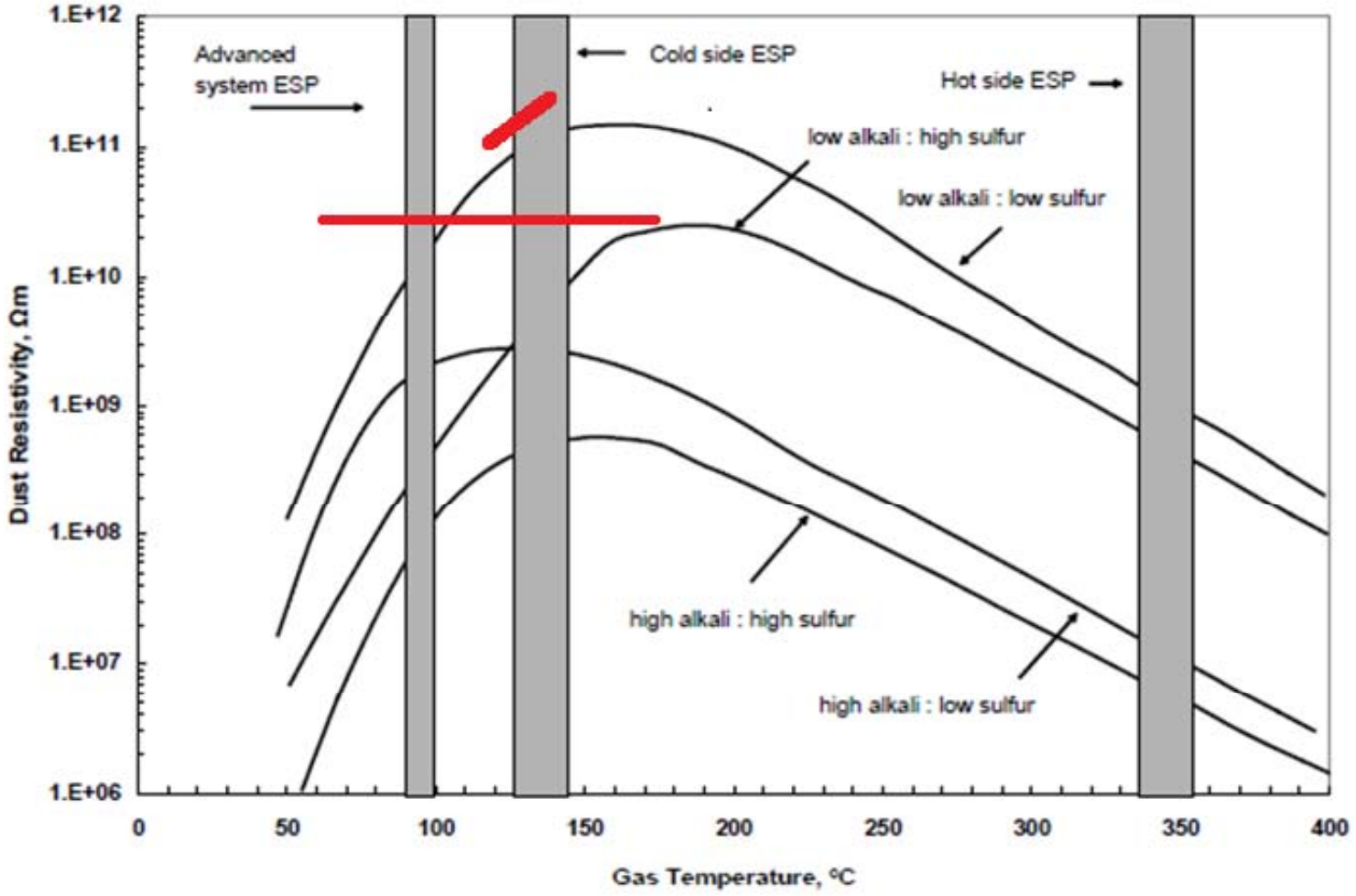
- Insulates Heat Transfer Surface ??
- Flattens The Element Surface Configuration And Reduces Turbulence for Convection
- Narrows Gas Passages and Increases Gas Velocity Through Element Passages

Ash and ABS Deposits

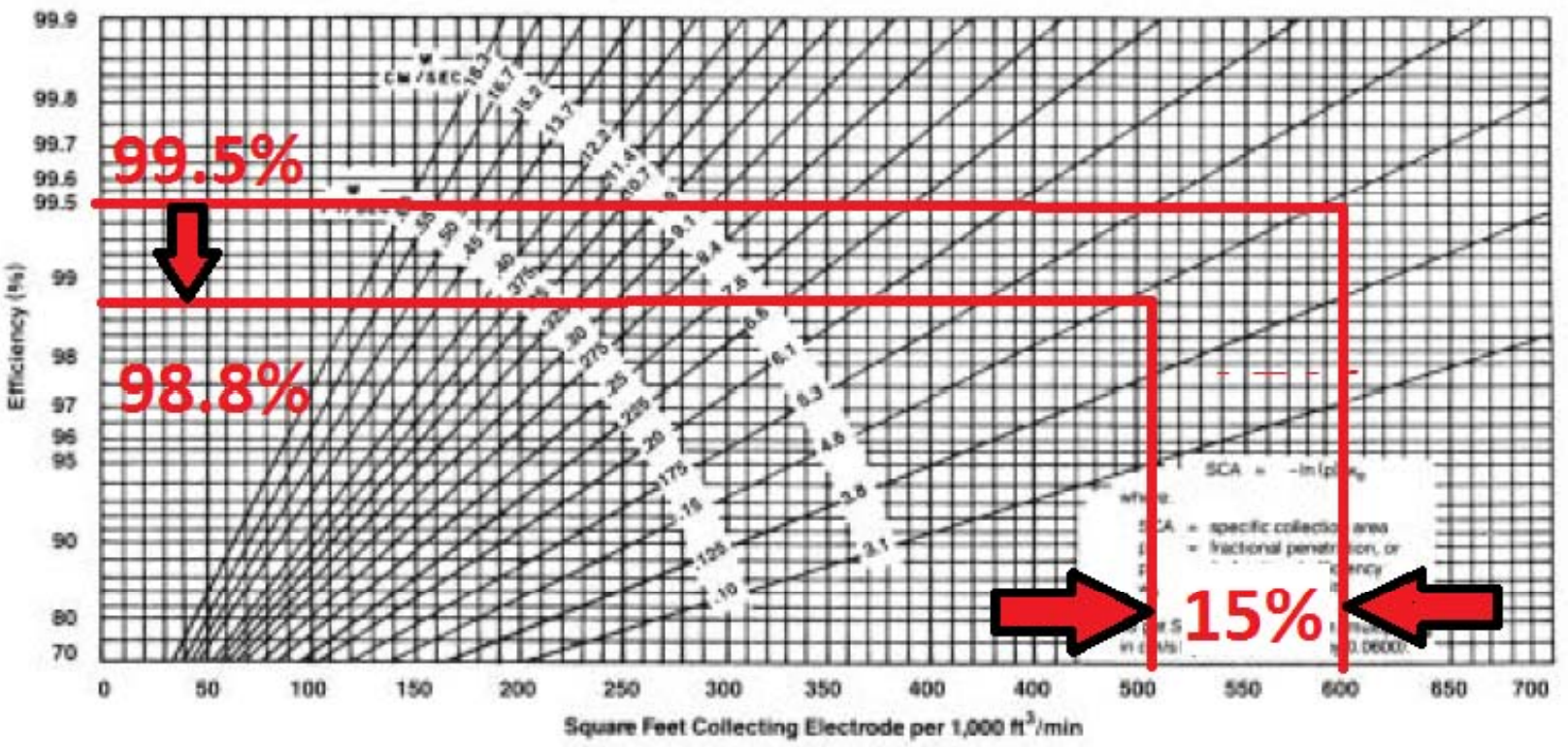
APC EFFECTS

- **ESP FLYASH RESISTIVITY**
- **ESP FLOW VOLUME - SCA**
- **FF PRESSURE DROP – BAG LIFE**

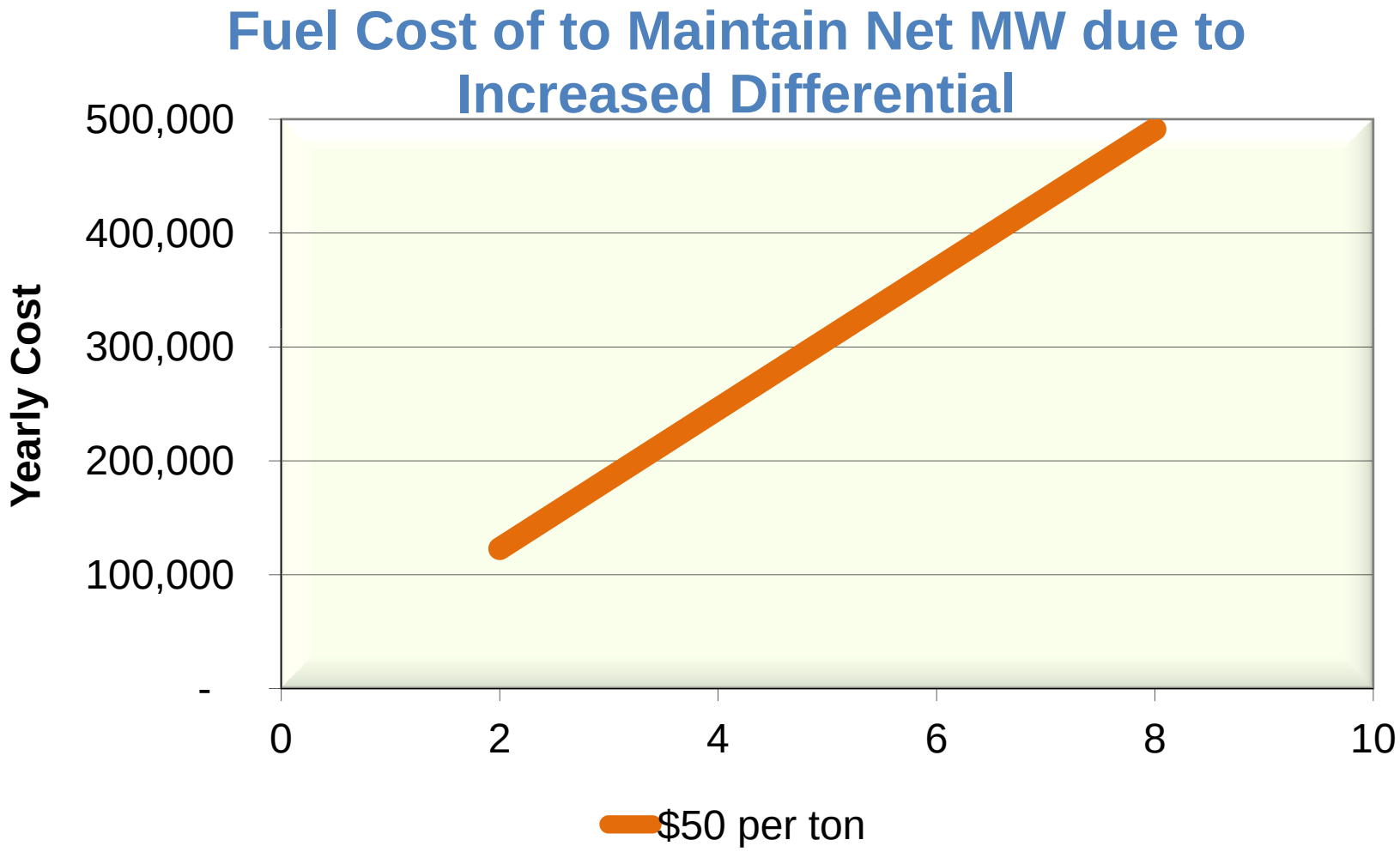
Fly Ash Resistivity



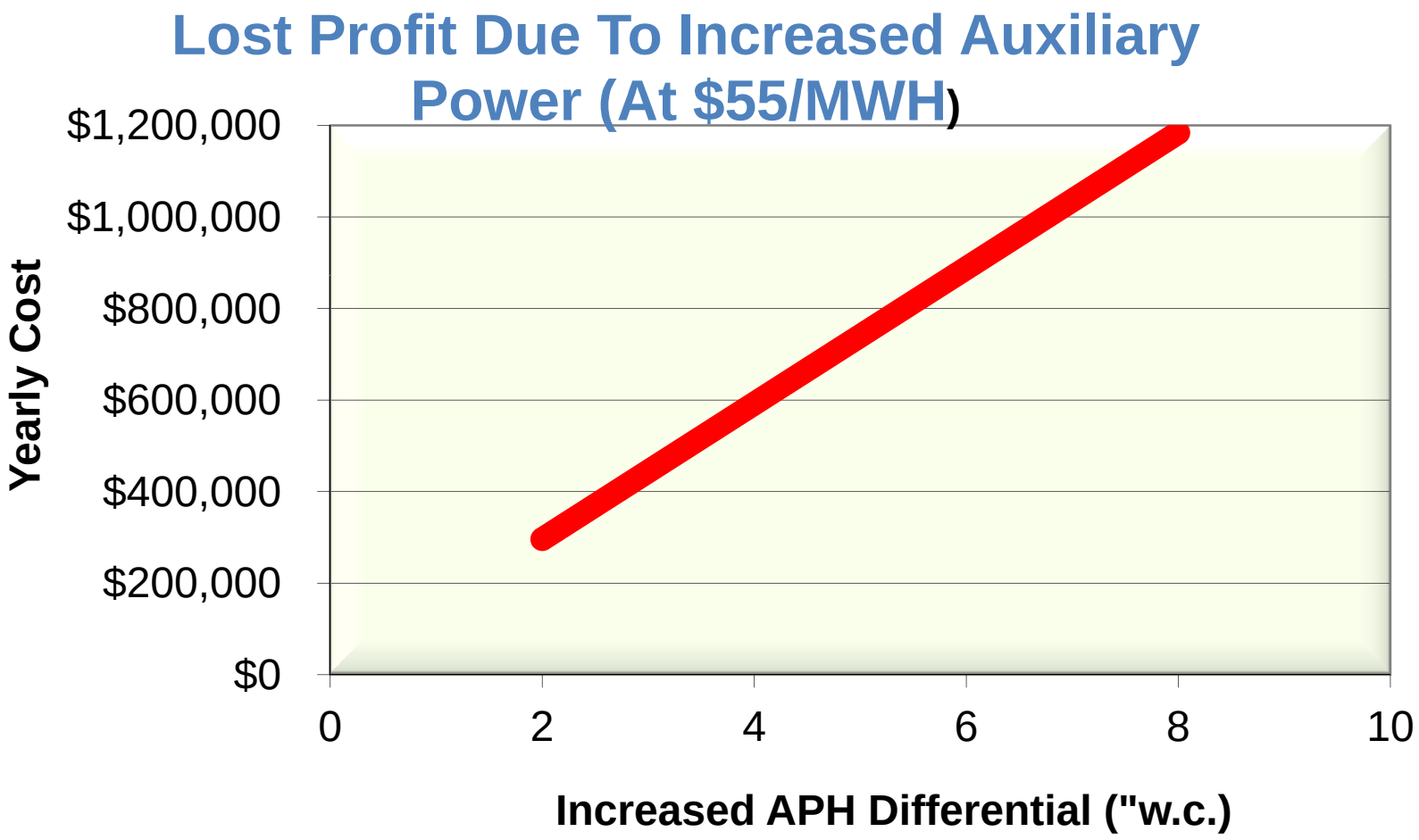
ESP Temperature and Volume



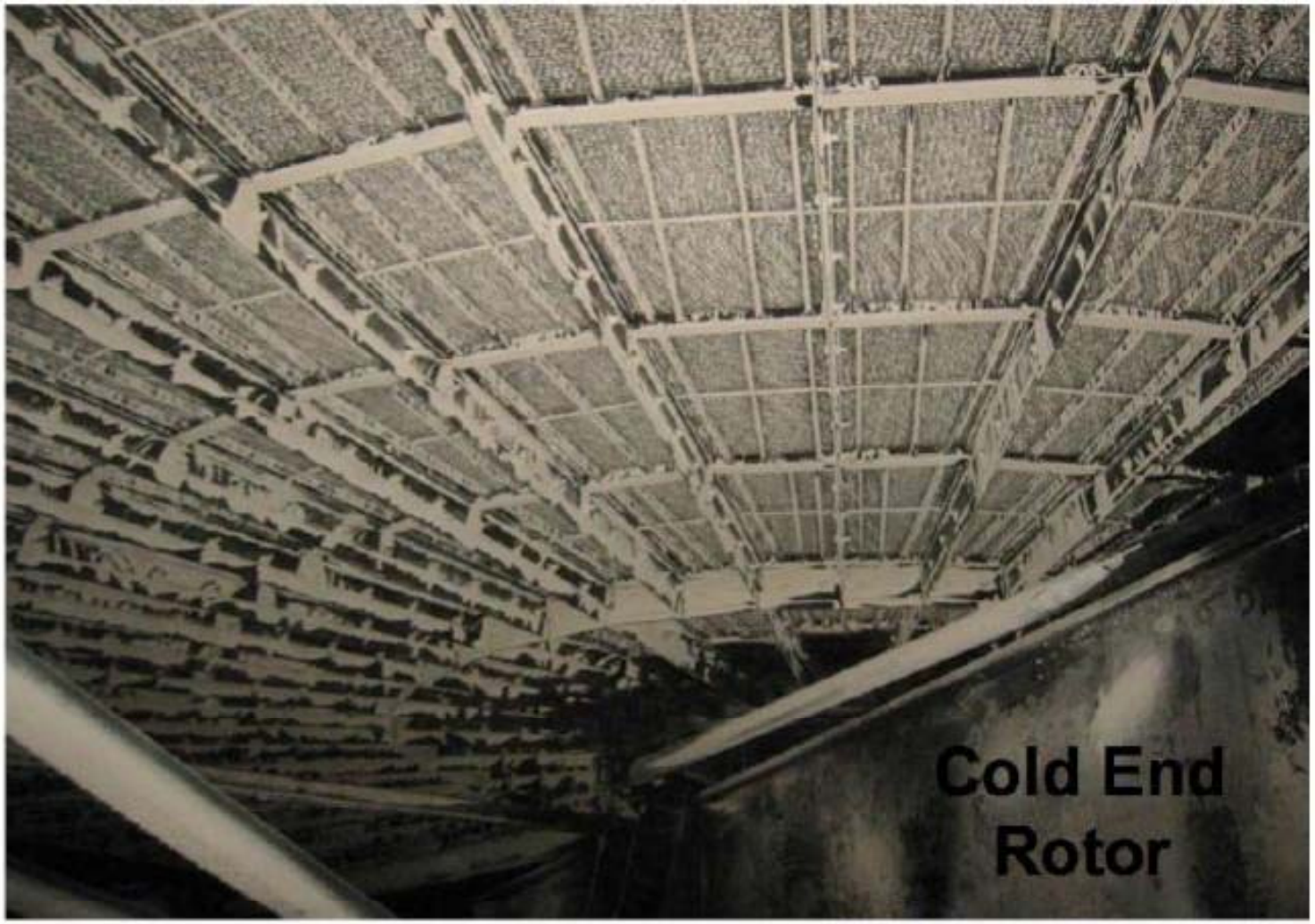
Pressure Drop Across The APH



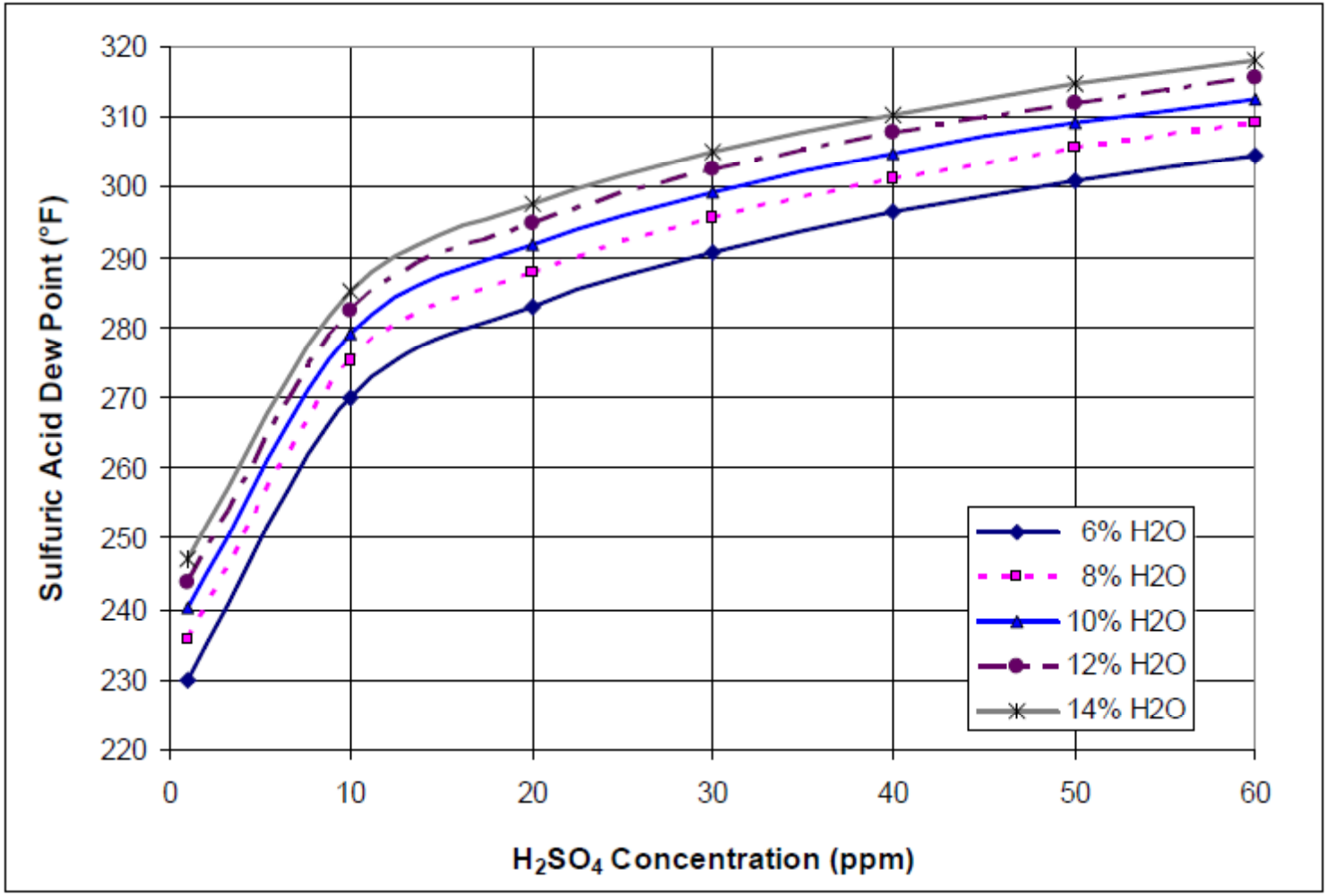
Increased Aux. Power = Lost Profit



Condensation Deposits



SO_3 Vs. Sulfuric Acid Dew Point Temp.



Ref. A&WMA, 2008 Mega Symposium,

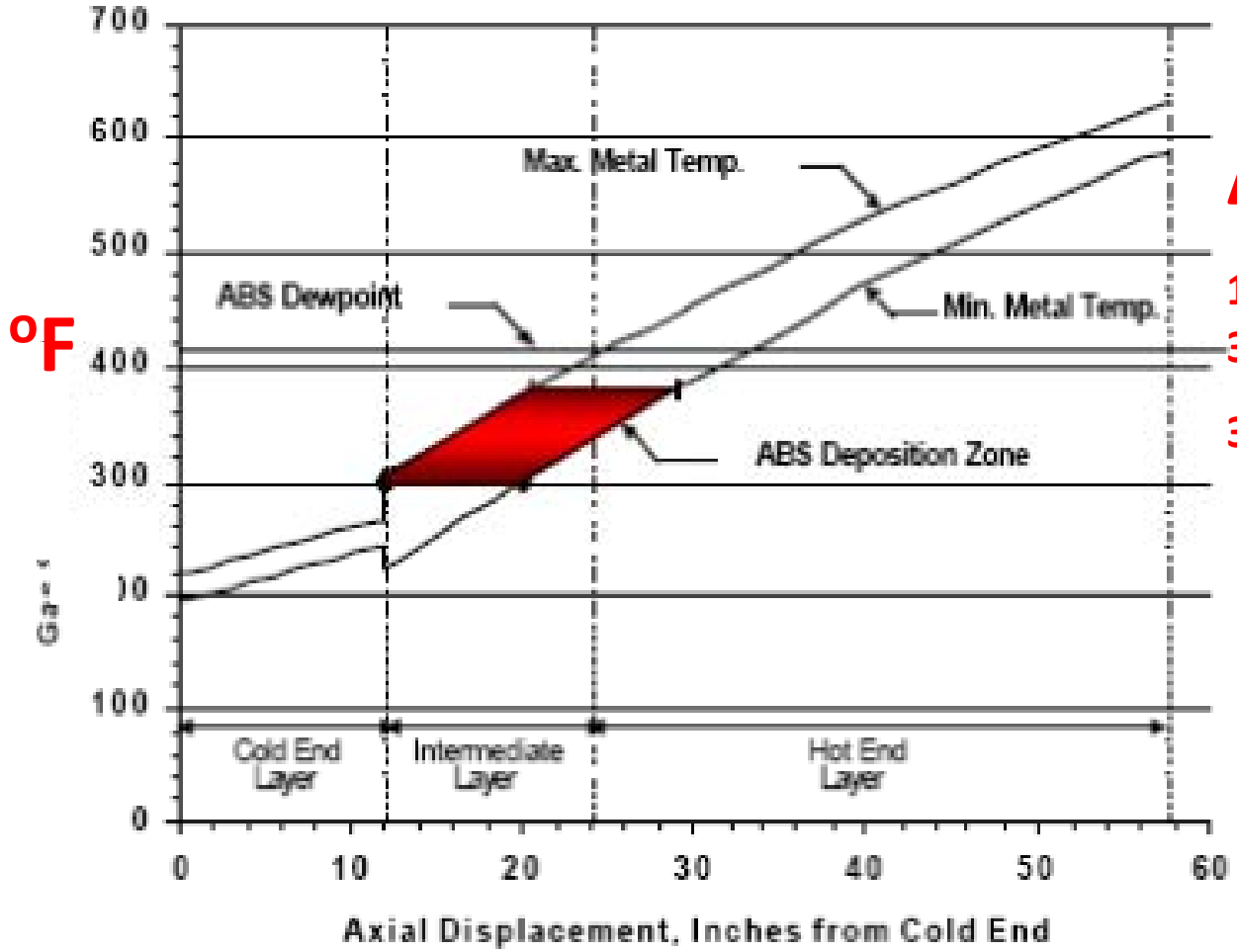
"The Effect of SO_3 Sorbents on Electrostatic Precipitator Performance", Paper # 75

Gas Outlet Temperature

- **Industry Standard :**
  - **A 10°F increase in airheater outlet temperature decreases the overall boiler efficiency by 0.25%.**
  - **10°F increases the annual fuel consumption by $ 300,000/yr**

Clean Cold End -- ABS Fouled

ABS Deposition Temperature

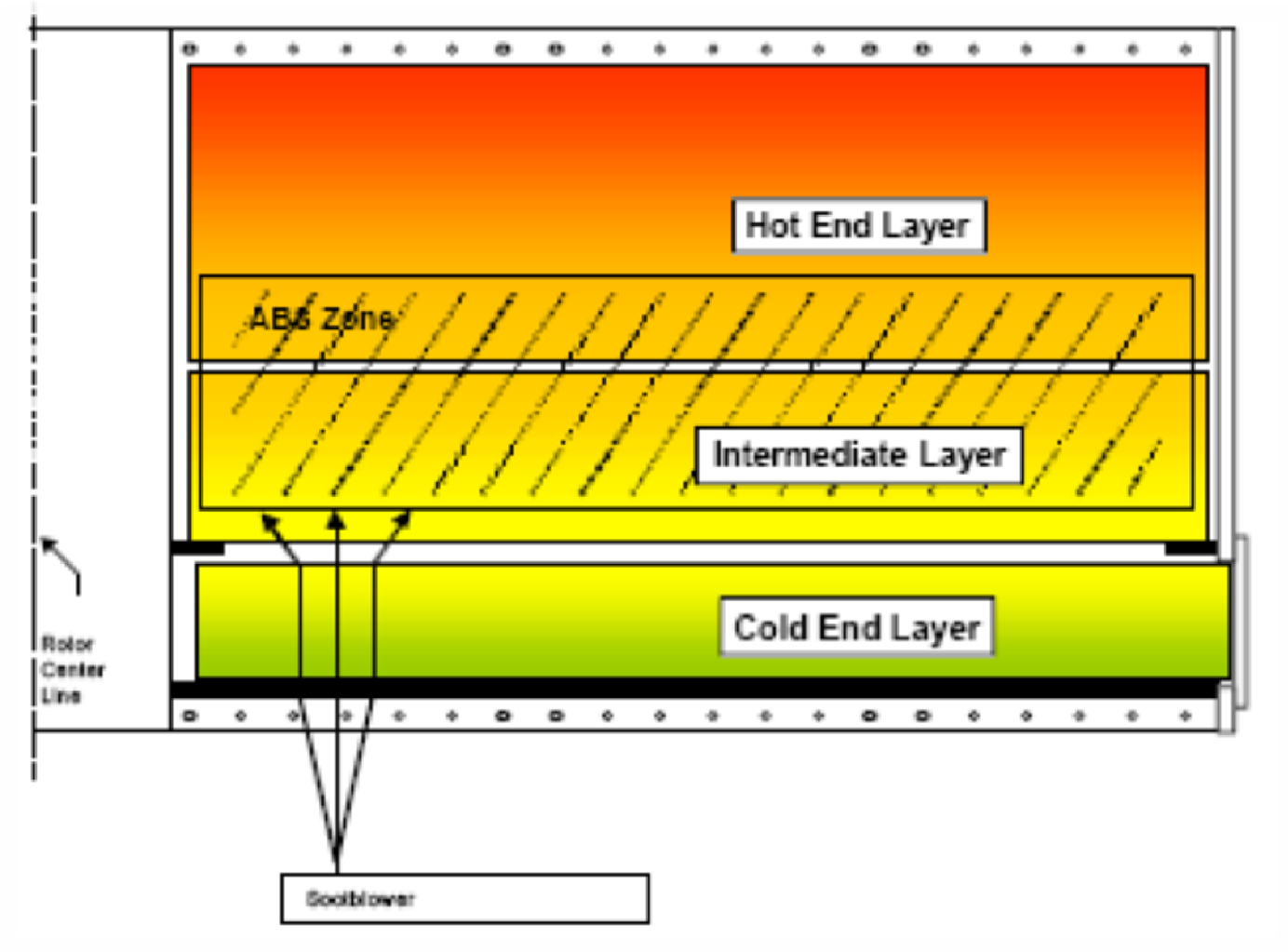


ABS

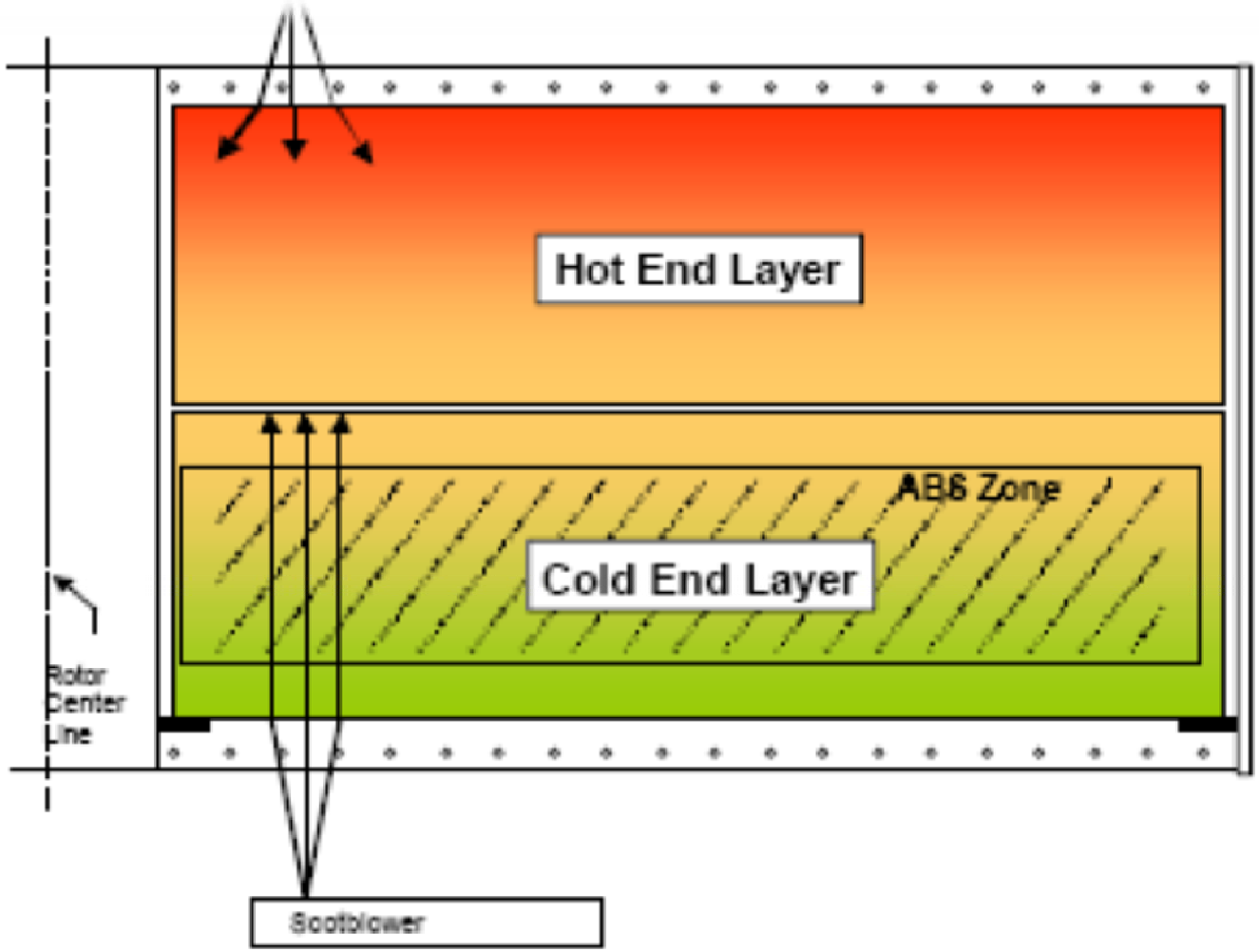
12 INCHES TO 30 INCHES

300°F TO390°F

ABS Zone – Three Layer

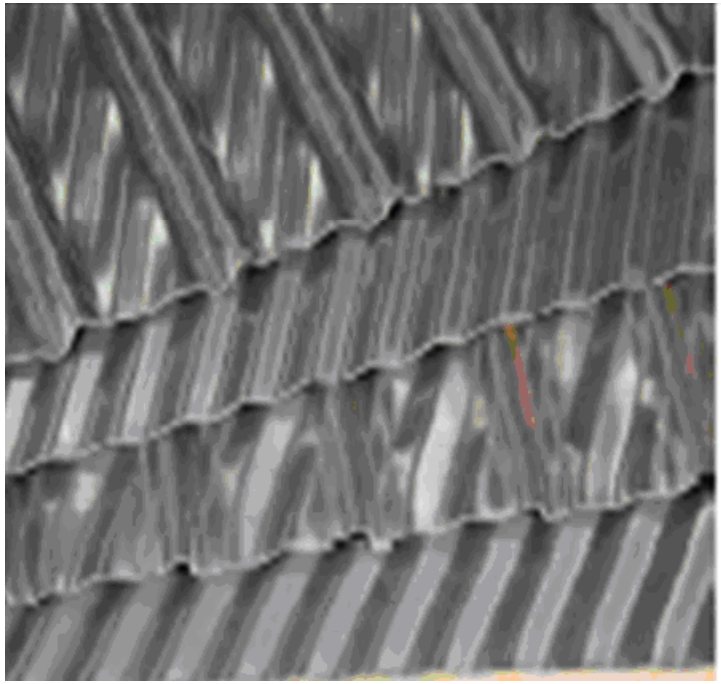


ABS Zone - Two Layer



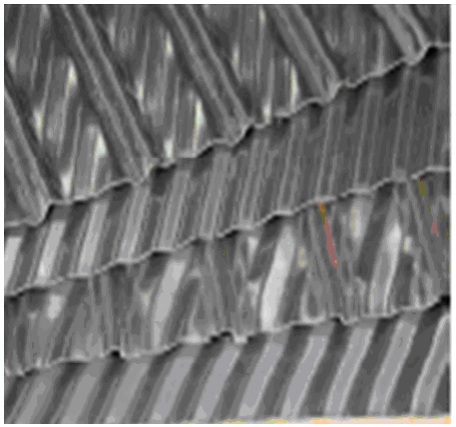
ABS Element Options

Standard



ABS Style

Heat Transfer Element



Two Layer Cold End Damage (Below)

Substrate Corrosion

Bromine for Hg Oxidation

- Br and/or HBr (Hydrogen Bromide)
- b.p. Br = 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 Corrosion

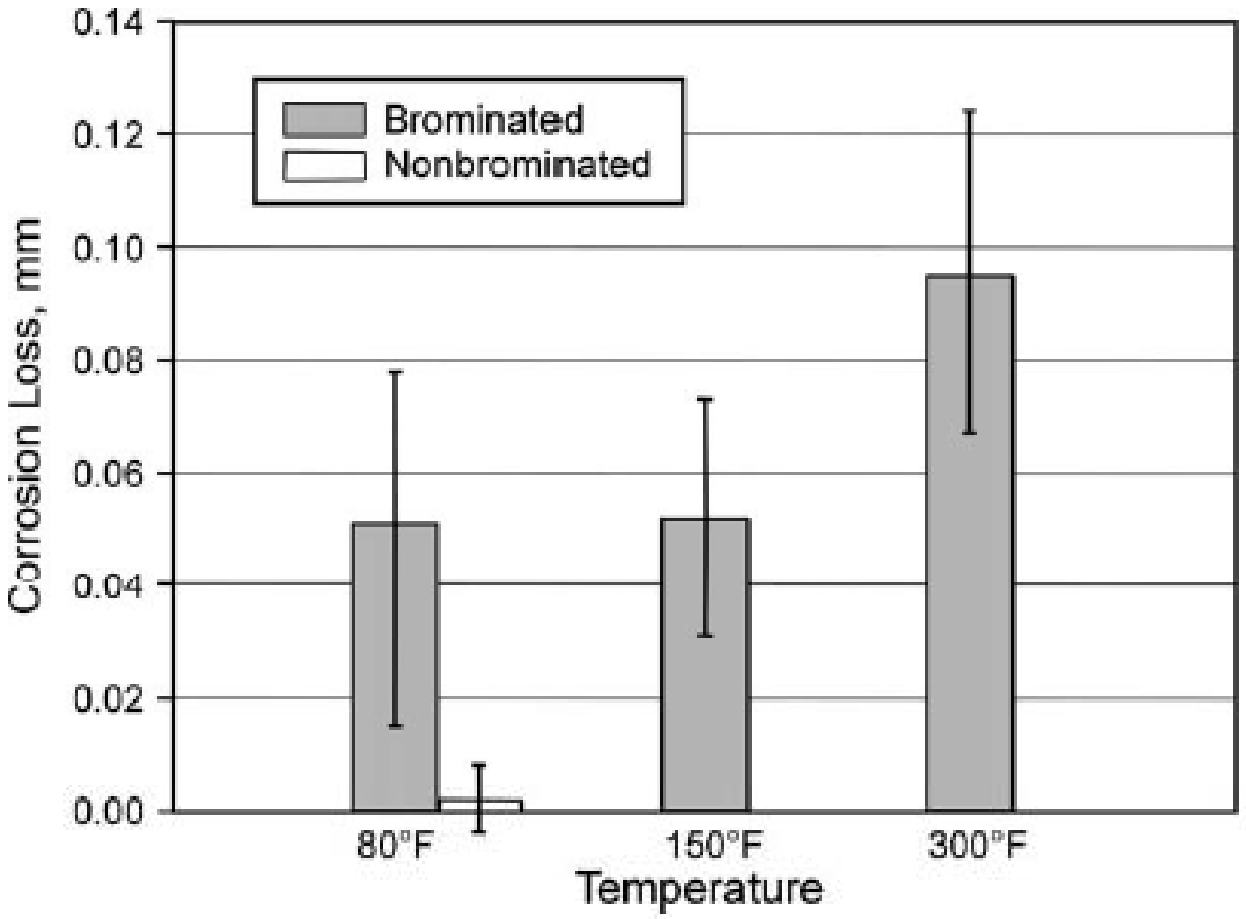
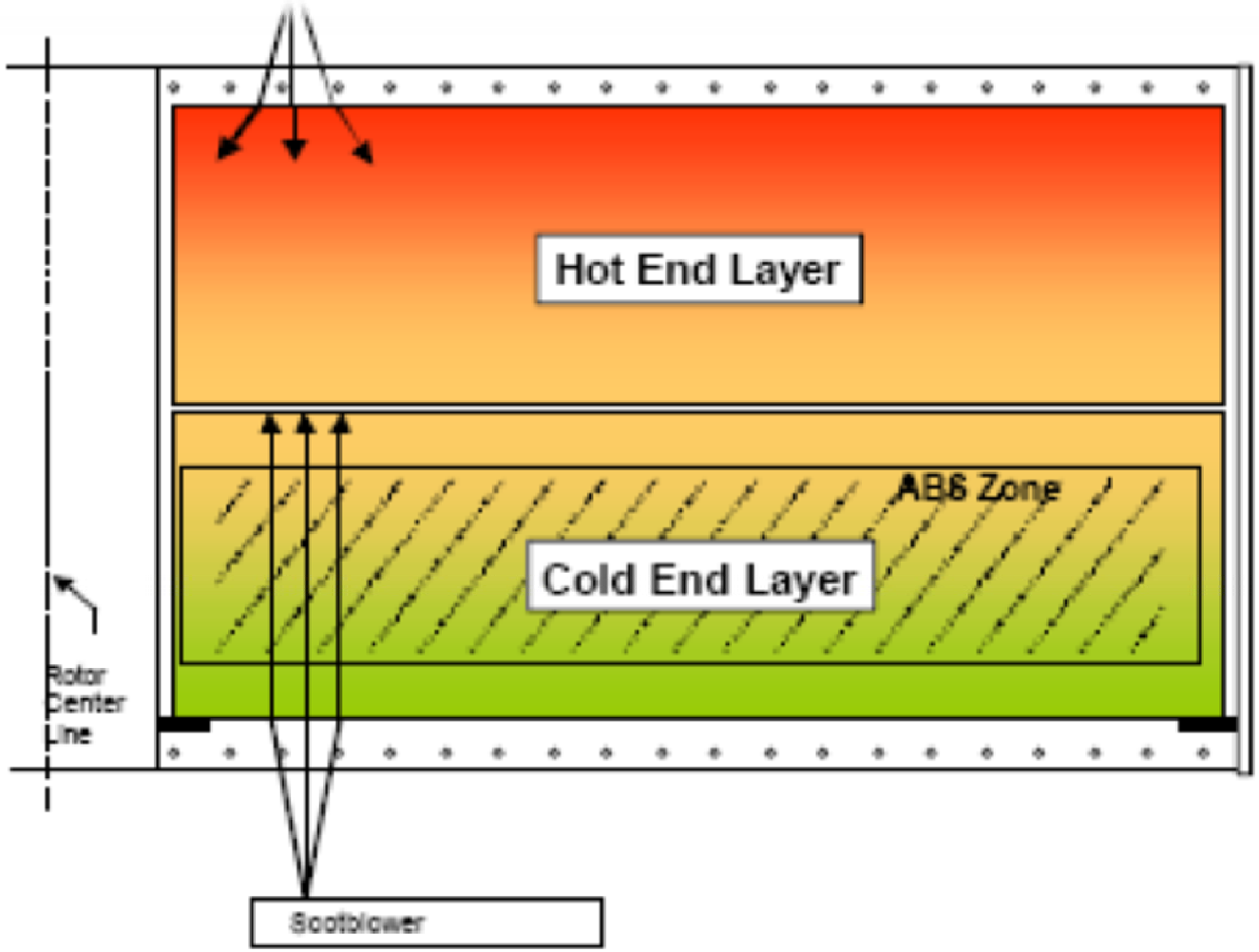
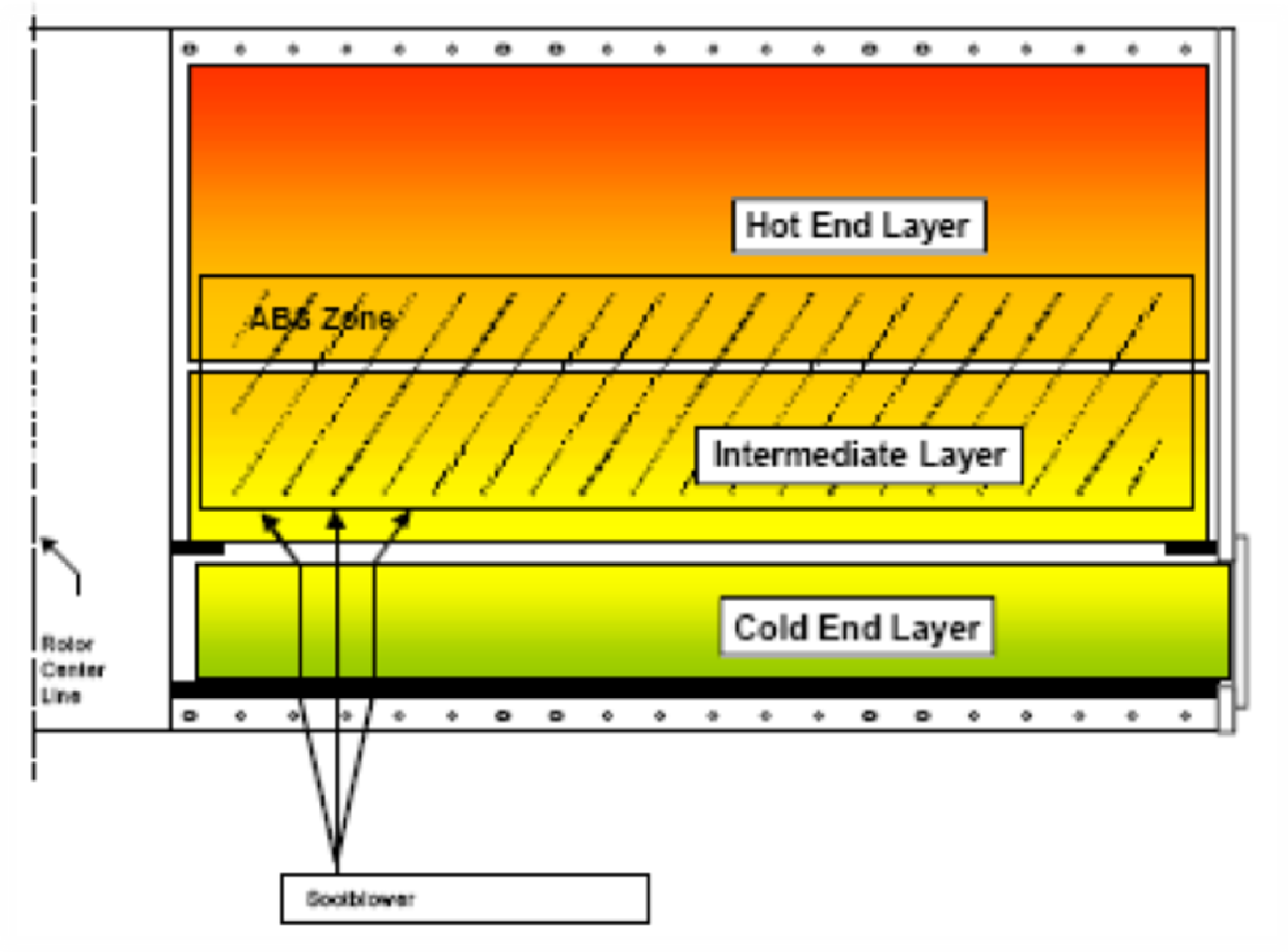


Fig. 3. Average corrosion loss in flue gas with/without 51 ppmv HBr for iron after 180 days. Maximum and minimum measured values are indicated.

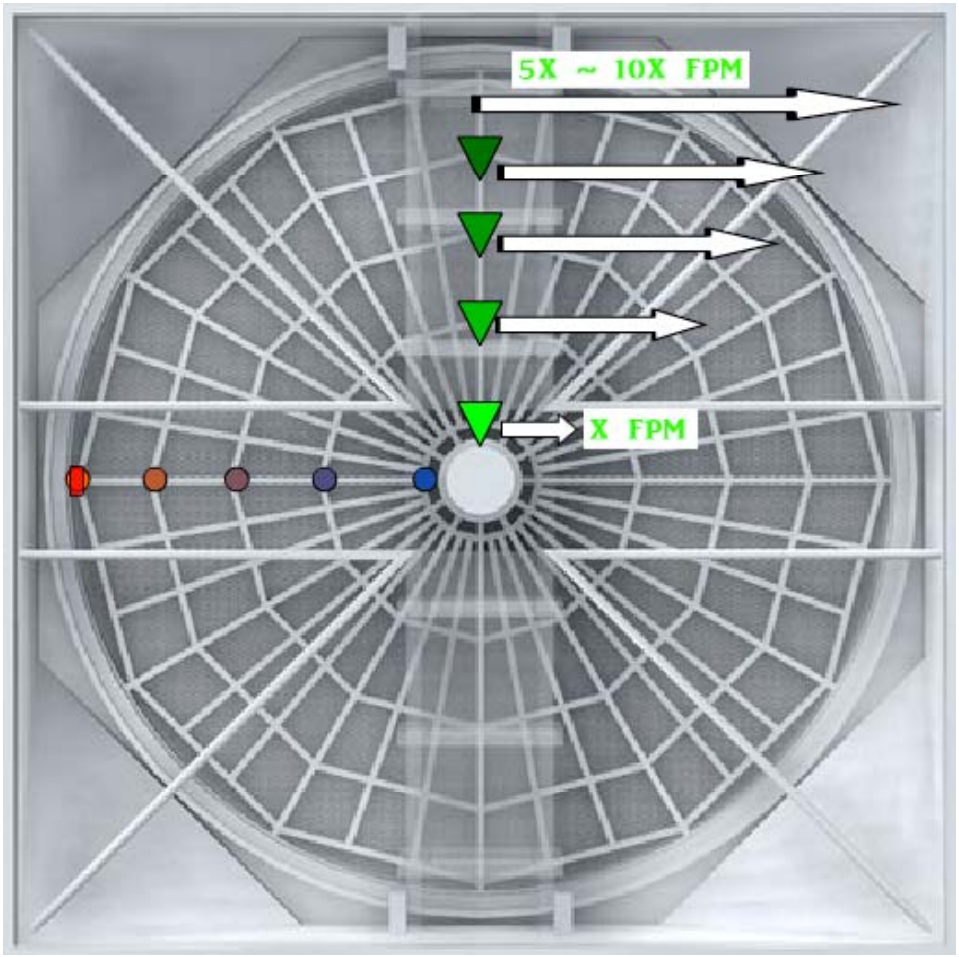
ABS Zone - Two Layer



ABS Zone – Three Layer

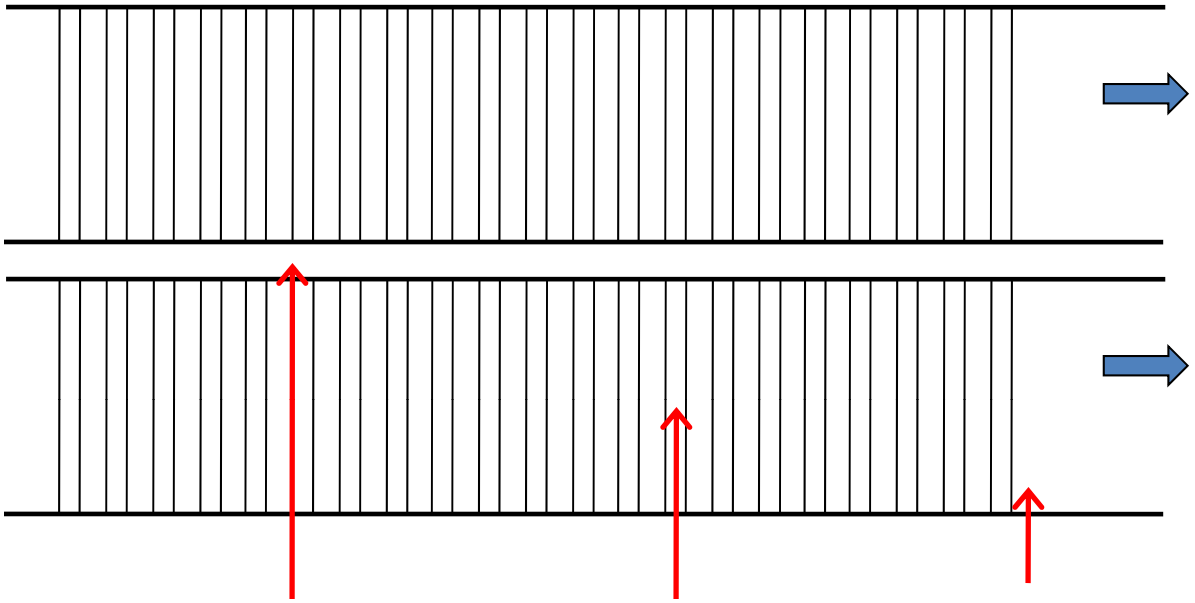


Angular Velocity/Sootblowing



Perimeter Angular Velocity Increases up to 10x

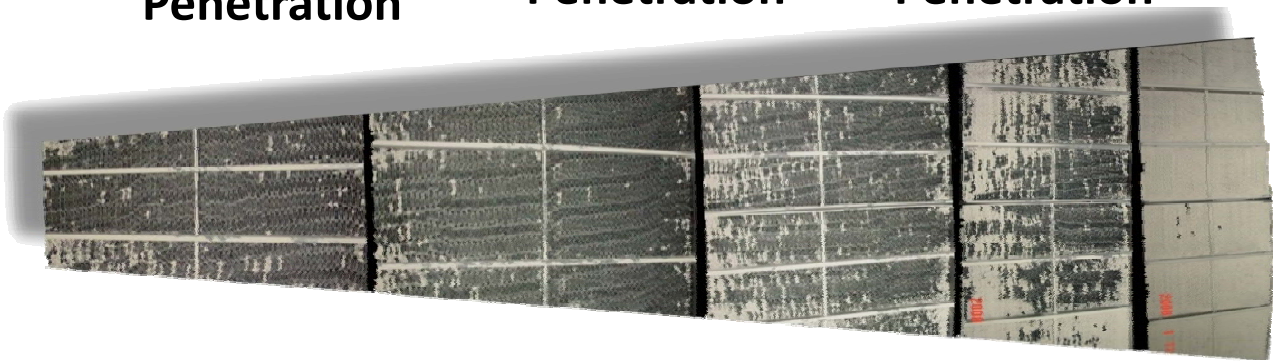
Soot Blower Penetration vs. Tangential Velocity



Slow Speed, Full Penetration

Medium Speed, Partial Penetration

High Speed, Reduced Penetration

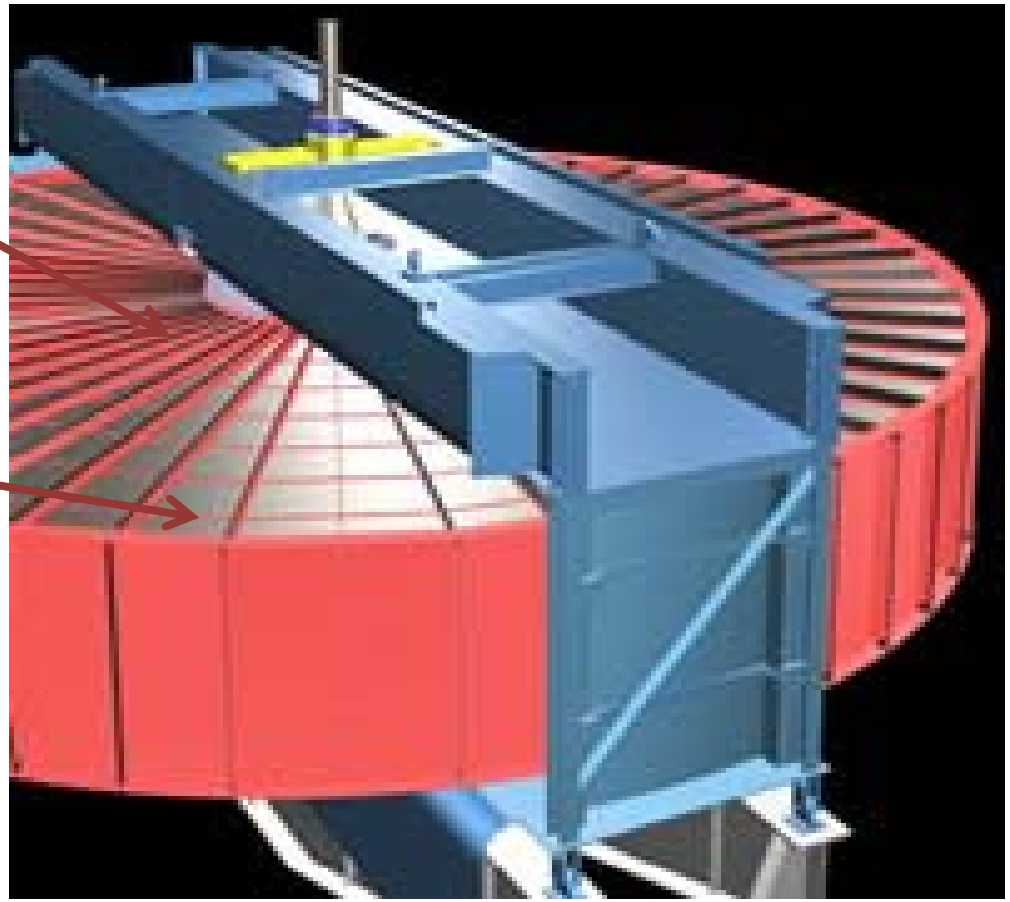


Soot Blower Penetration vs. Tangential Velocity

Penetration Depth is greater here:

Than it is here:

Due to significant differences in angular velocity

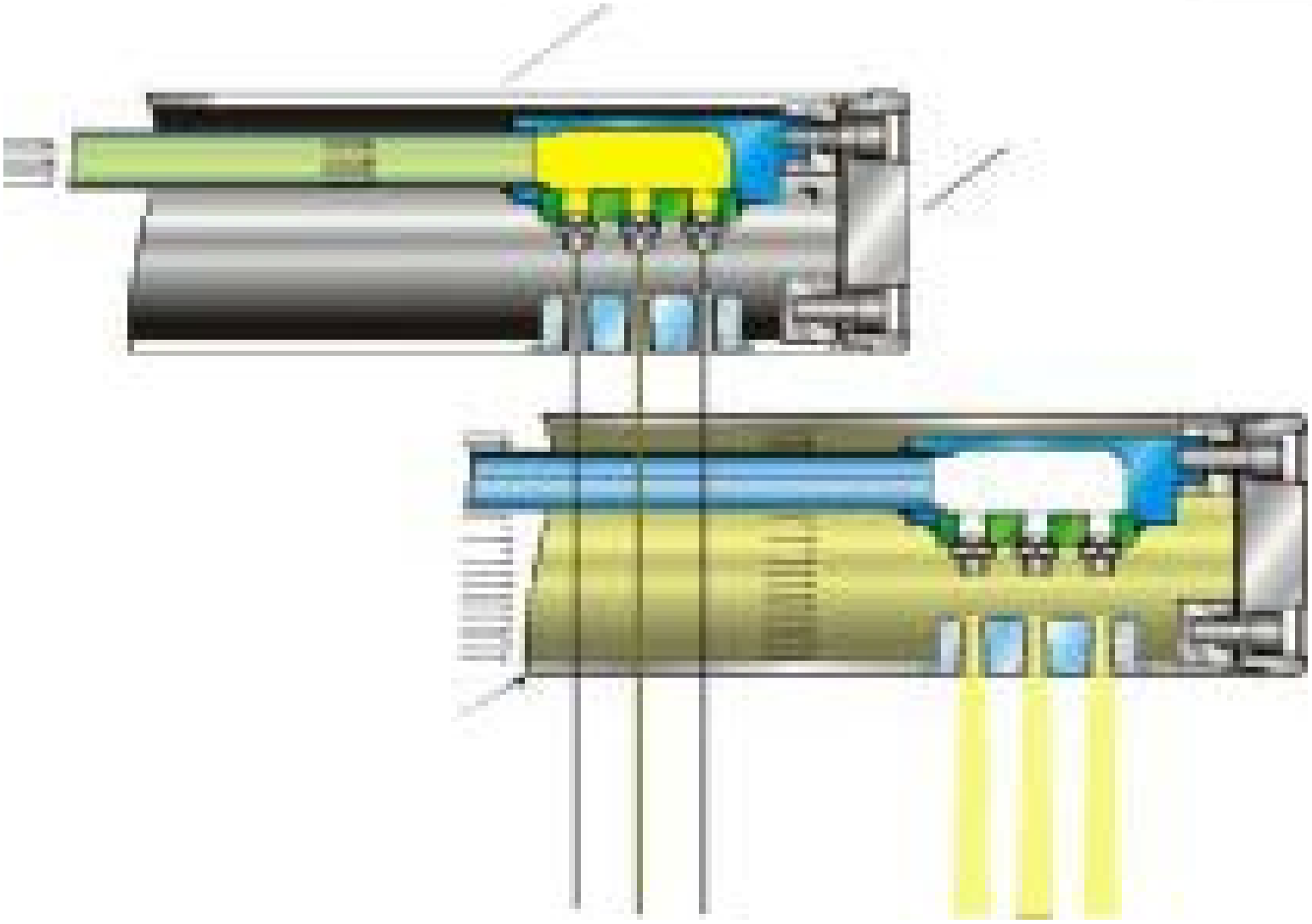


Dynamic Speed Control (DySC)

- **Sootblower logic is modified to allow the nozzle to be positioned as desired, and then left stationary**
- **The Rotor speed is coordinated with the nozzle position to provide suitable residence time.**

Soot Blowers

Dual Media Blower



Dual Media Blower

ABS Prevention

Measure ABS Formation Temperature

AbSensor – AbS/SO3 System

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

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

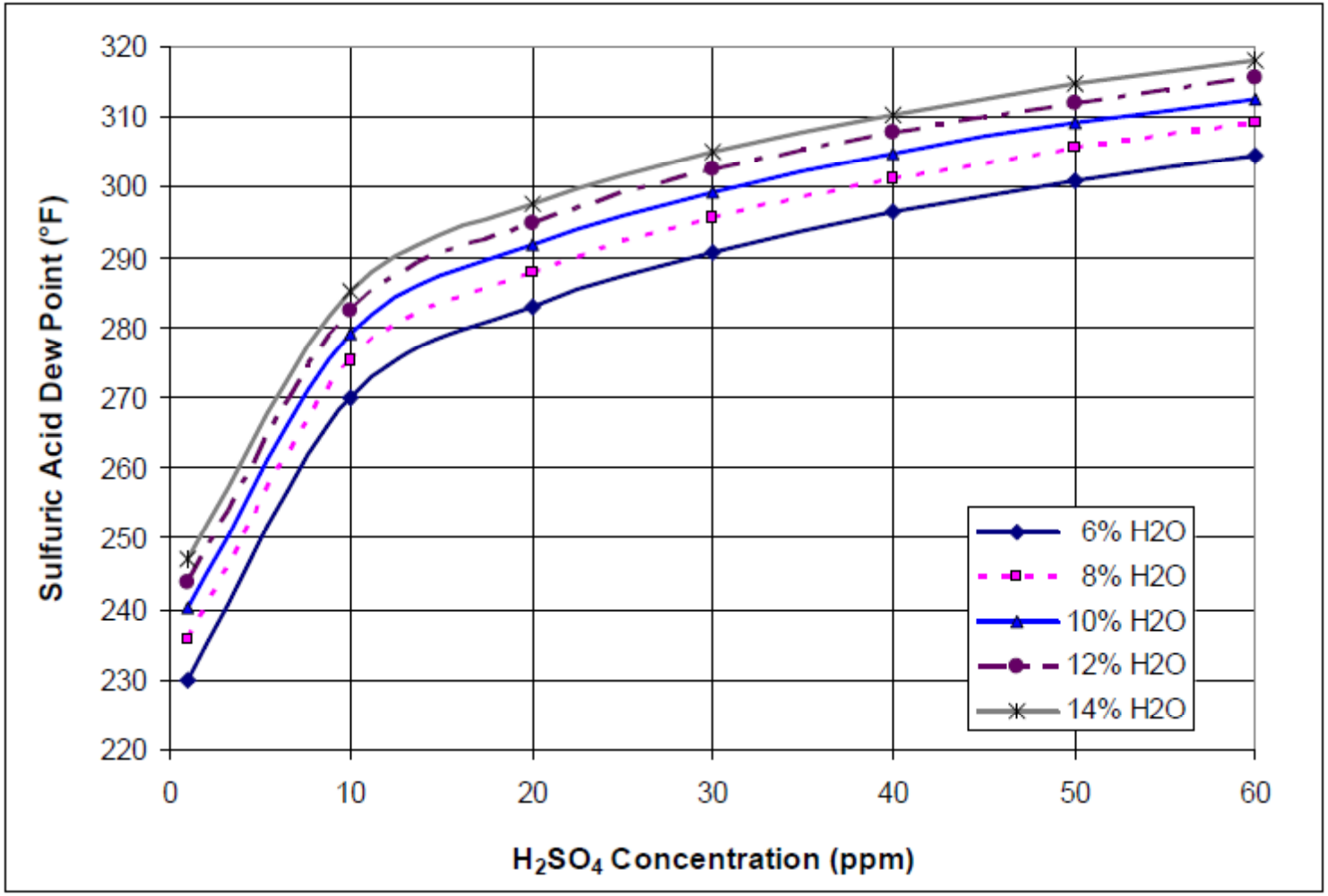
Bring ABS Deposits Closer to the Cold End

- 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

SO_3 Vs. Sulfuric Acid Dew Point Temp.



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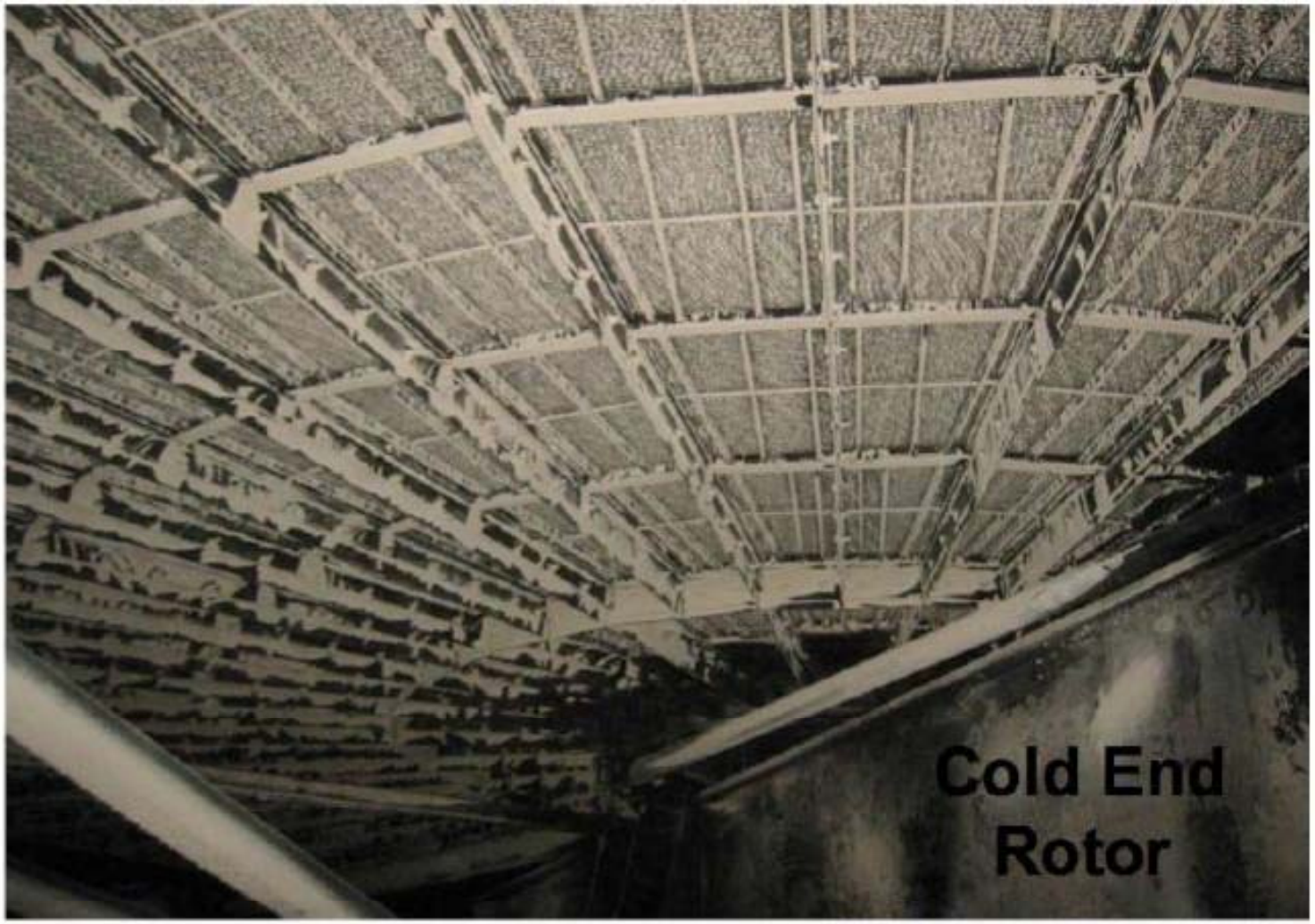
Condensation Deposits



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