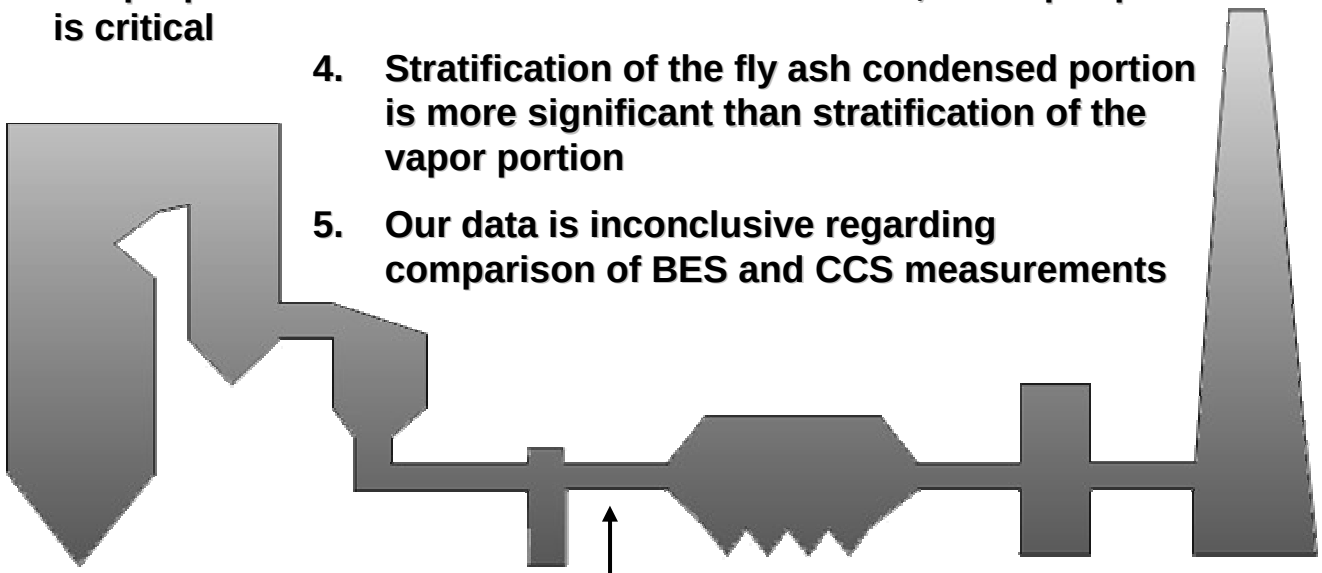
Reinhold Environmental Ltd.

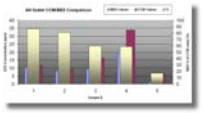
2008 NOx-Combustion Round Table & Expo Presentation

February 4-5, 2008 in Richmond, VA

Air Heater Outlet Comparison

1. Total SO_3 includes acid vapor and acid material condensed on the fly ash
2. For purposes of ESP performance the condensed portion is critical
3. For purposes of corrosion or Blue Plume control, the vapor portion is critical
4. Stratification of the fly ash condensed portion is more significant than stratification of the vapor portion
5. Our data is inconclusive regarding comparison of BES and CCS measurements





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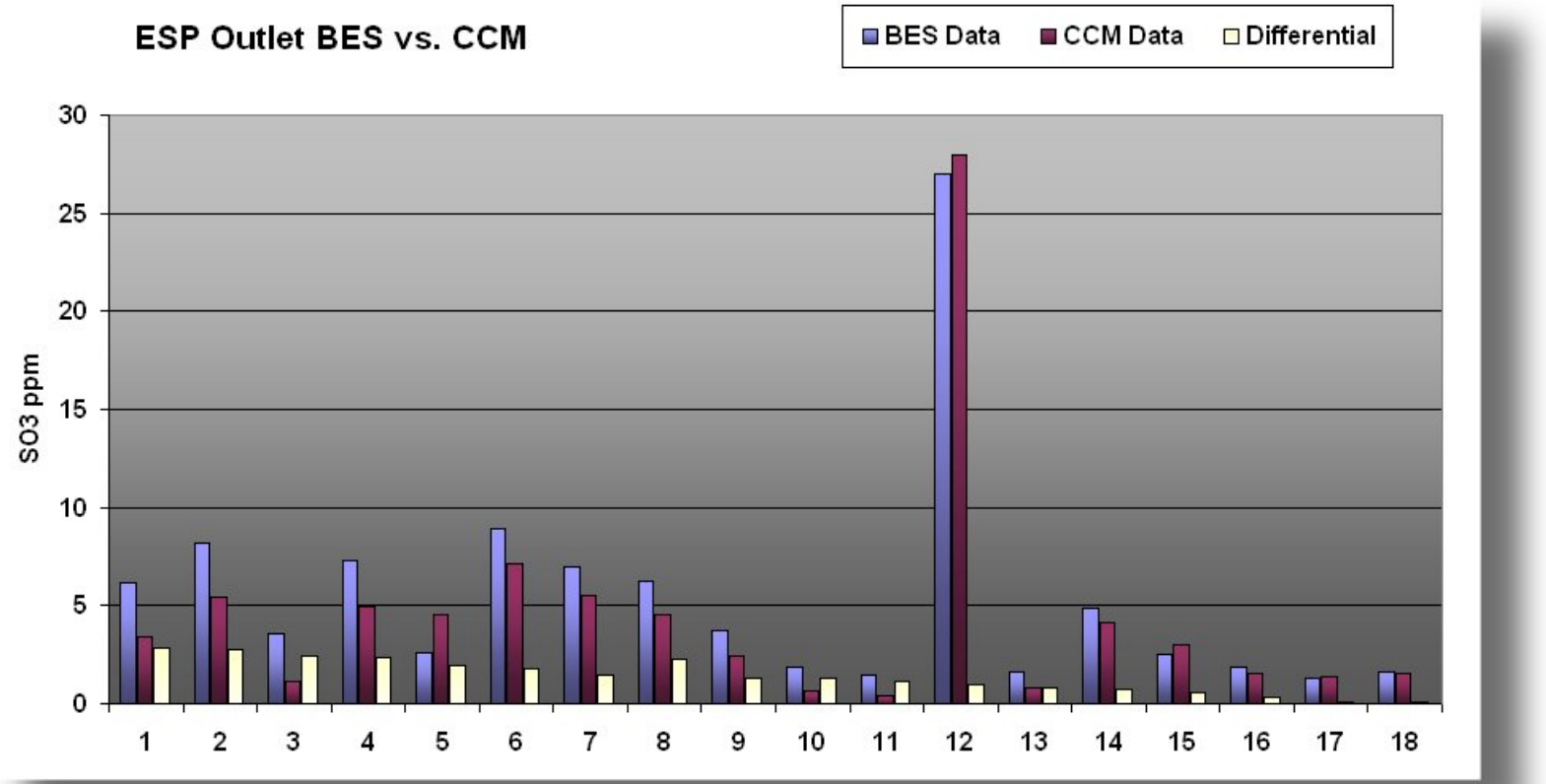
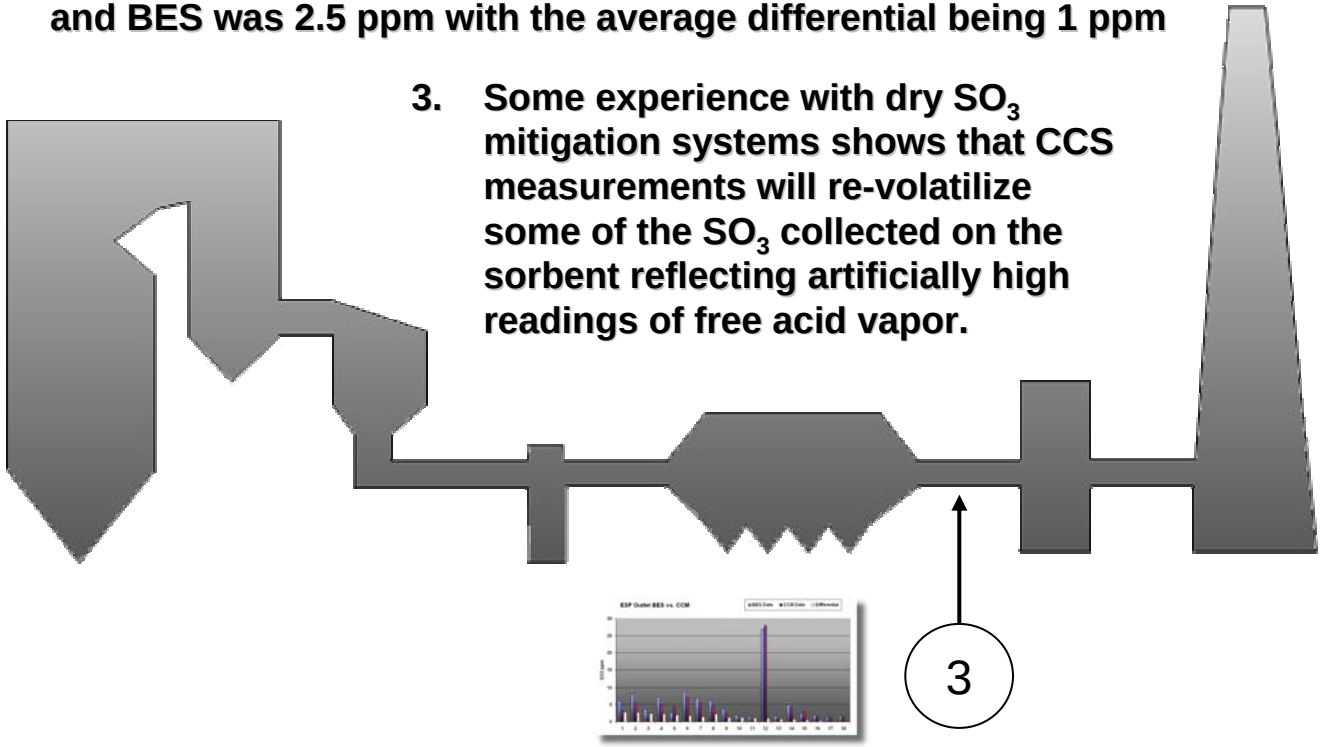
ESP Outlet Comparison



ESP Outlet Comparison

1. With the fly ash, and the acid condensed on the fly ash, removed the CCM and BES data should both reflect the vapor portion only
2. Covering the data collected so far, the maximum differential between CCM and BES was 2.5 ppm with the average differential being 1 ppm
3. Some experience with dry SO_3 mitigation systems shows that CCS measurements will re-volatilize some of the SO_3 collected on the sorbent reflecting artificially high readings of free acid vapor.



SO3 Measurement Comparison Conclusions

- **The readings between CCS and BES can be correlated if the location in the gas train is considered:**
  - **Pre-Air Heater the BES readings will be lower due to temperature equilibrium effects. The magnitude of the differential should be site specific**
  - **Post Air Heater the BES readings will be lower due to fly ash condensed vapor factors. The stratification and position in the duct must be considered**
  - **Post ESP the CCS and BES readings are virtually identical**

Ammonia Effects

- **Ammonium Bisulfate measurements can only be made at the Pre-Air Heater location**

- **If AbS is present, the free SO3 reading at the Pre-Air Heater location will be reduced by the amount of AbS formed. In some instances, with high levels of AbS, there may be zero free SO3 vapor**

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Conclusion

- **In the end:**
  - **If you need to compare your data to previous data for compliance purposes, the CCS method will suit your needs best,**
  - **If you are looking for a real time sensor to control one or more plant processes, the BES method is superior**
- ***The next section will explore a case study of closed loop methods for control of AbS/SO_3 formation and Air Heater fouling from AbS or Acid deposition***

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ABS Measurement & Control Experience

EMISSIONS CONTROL PROCESS ENHANCEMENT

NOX | MERCURY | ASH QUALITY

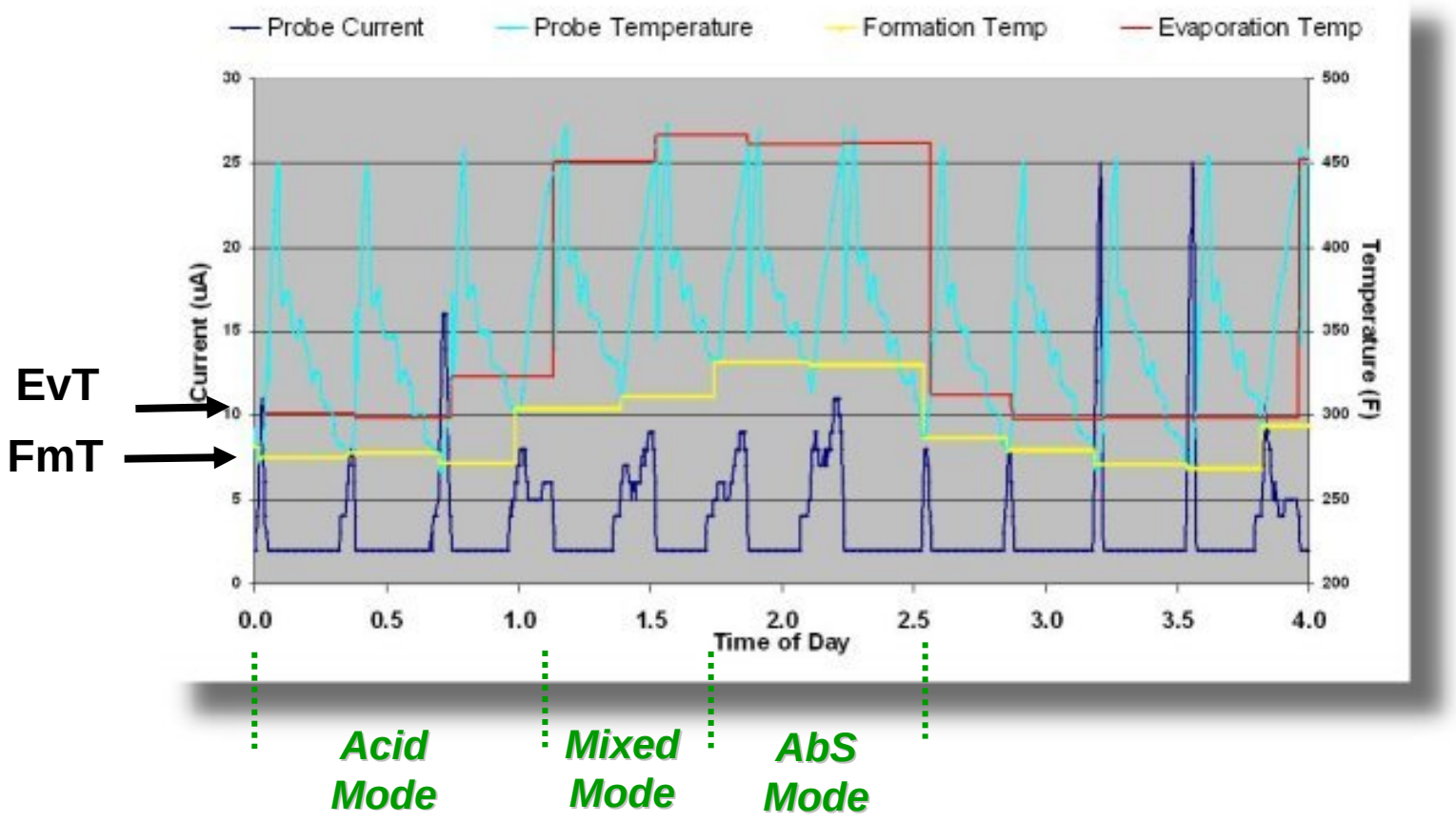
Dual Mode NOx Control

- **NOx reduction limitations are often based on air heater fouling considerations**

- **Avoiding Air Heater Fouling requires combined control of:**
  - **Ammonia Material Injection rate**
  - **Air Heater Cold End Metal Temperatures**

- **The AbSensor Dual Mode Controller provides integrated control of both facets**

Mixed Mode Condensable Deposition



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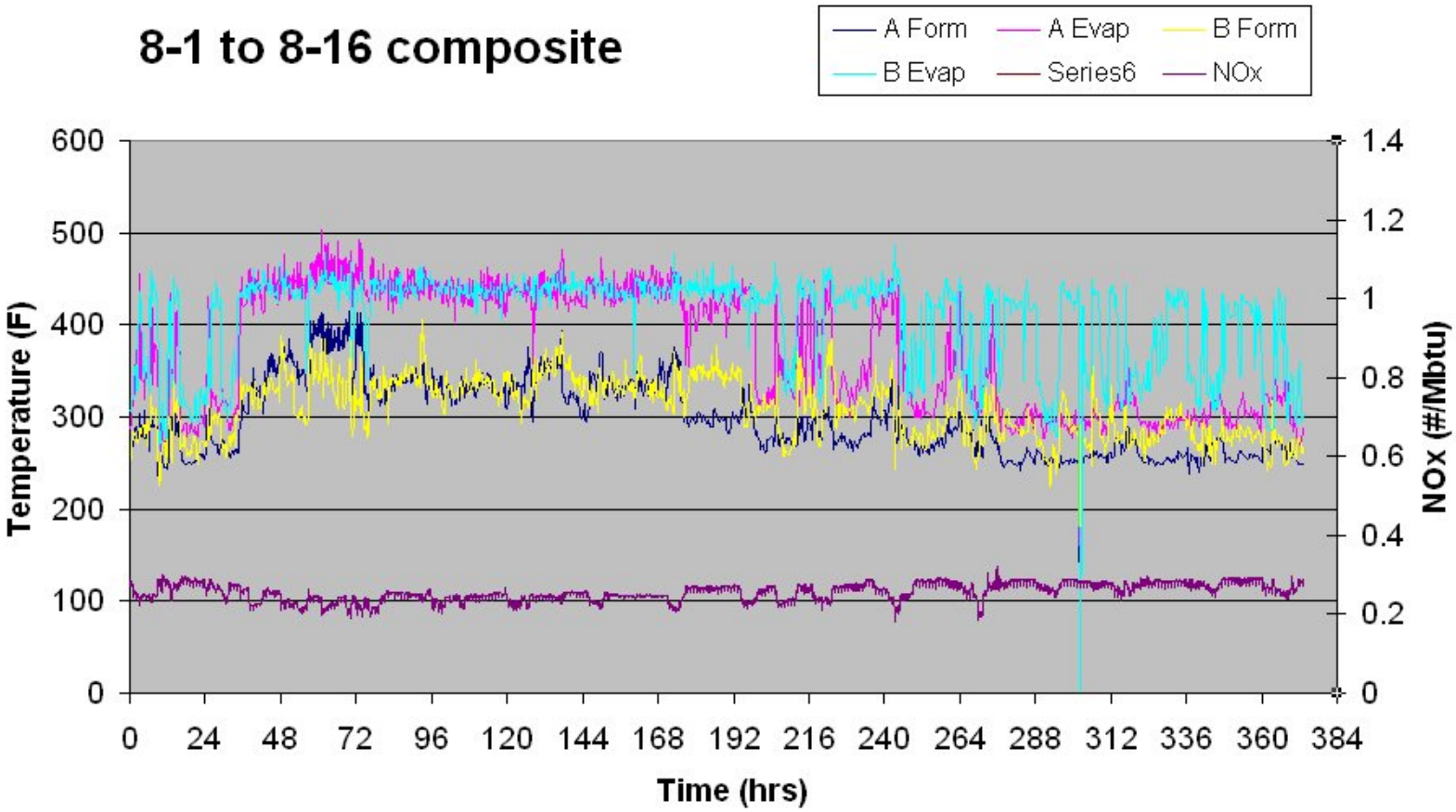
Spatial NH_3 Balancing



FmT/EvT Relationships

- **What can we learn from the relationship between FmT and EvT:**

1. **Low FmT & Low EvT (generally within 30 degrees of each other) suggests non-NH_3 effected sulfuric acid**
2. **High FmT (>330°F) and high EvT (450°F - 480°F) means traditional Ammonium Bisulfate**
3. **High EvT (450°F - 480°F) with low FmT (<300°F) means lean phase AbS on a sulfuric acid condensate base**
4. **Low FmT (<280°F) and Ultra High EvT (>500°F) indicates a non-ideal, hydrated sulfuric acid condensate base with lean NH_3 attached**

Control Mechanisms

1. **Low FmT/Low EvT – Bias NH_3 Positively until EvT exceeds 450F**

2. **High FmT/High EvT – Bias NH_3 Negatively Until FmT drops below 300F**

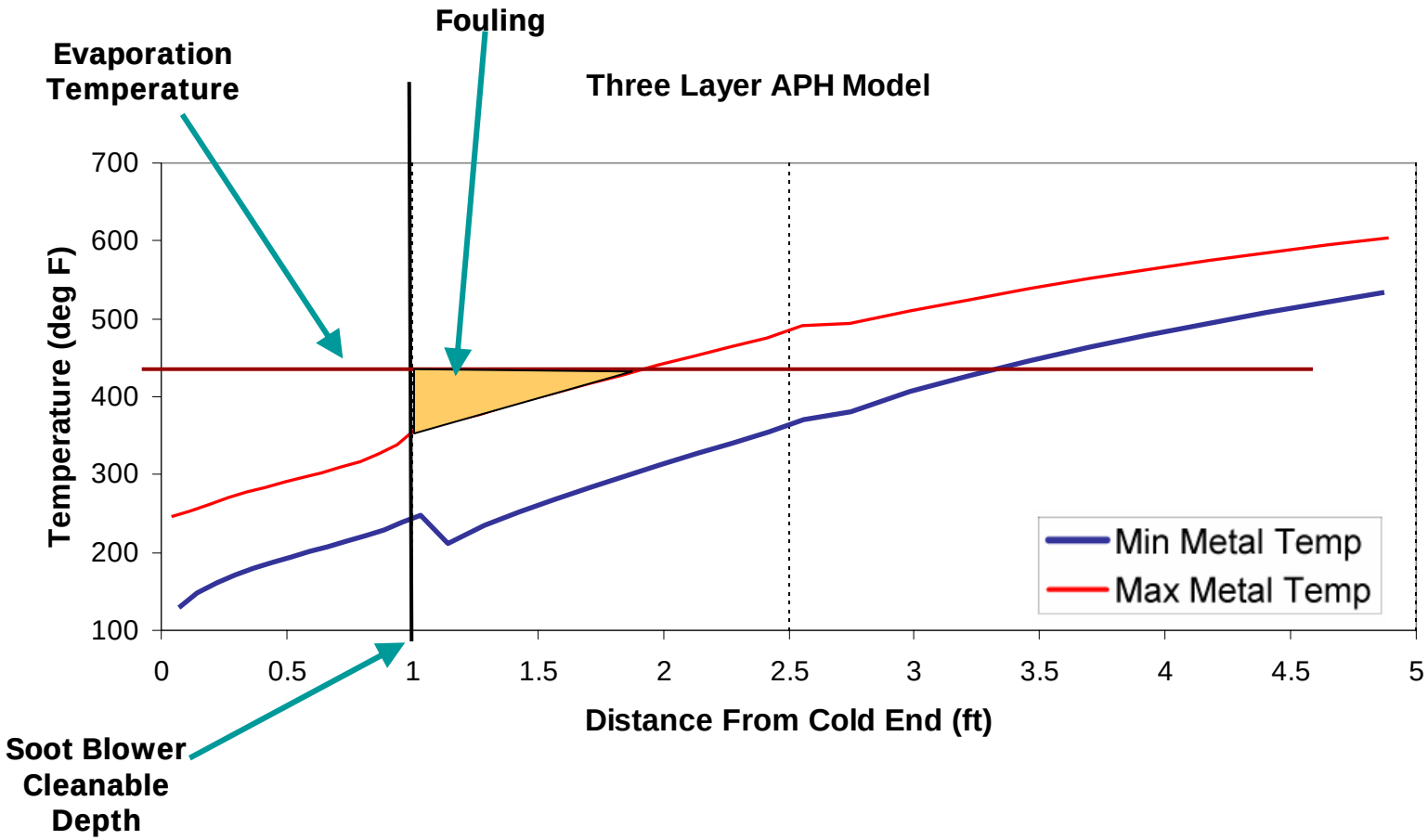
3. **Low FmT/High EvT – maintain status quo**

4. **Ultra High EvT – Increase NH_3**

Air Heater Fouling Breen Model*

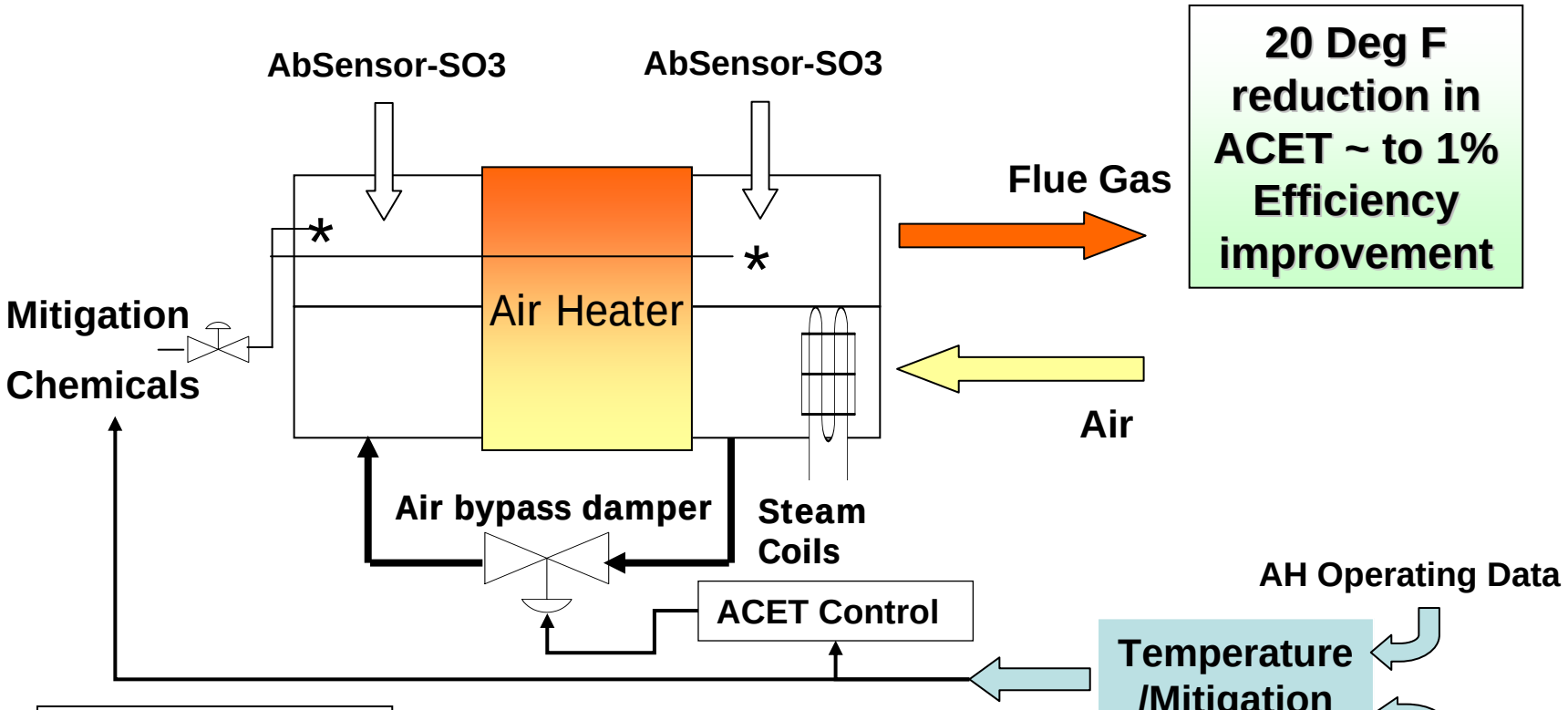
Increase Air Heater Outlet Temperature

Reduce Ammonia Flow



* Licensed from EPRI; developed by Lehigh

Integrated Air Heater Temperature/Mitigation Controller



- Hydrated Lime
- Trona,
- MgOH
- Ammonia

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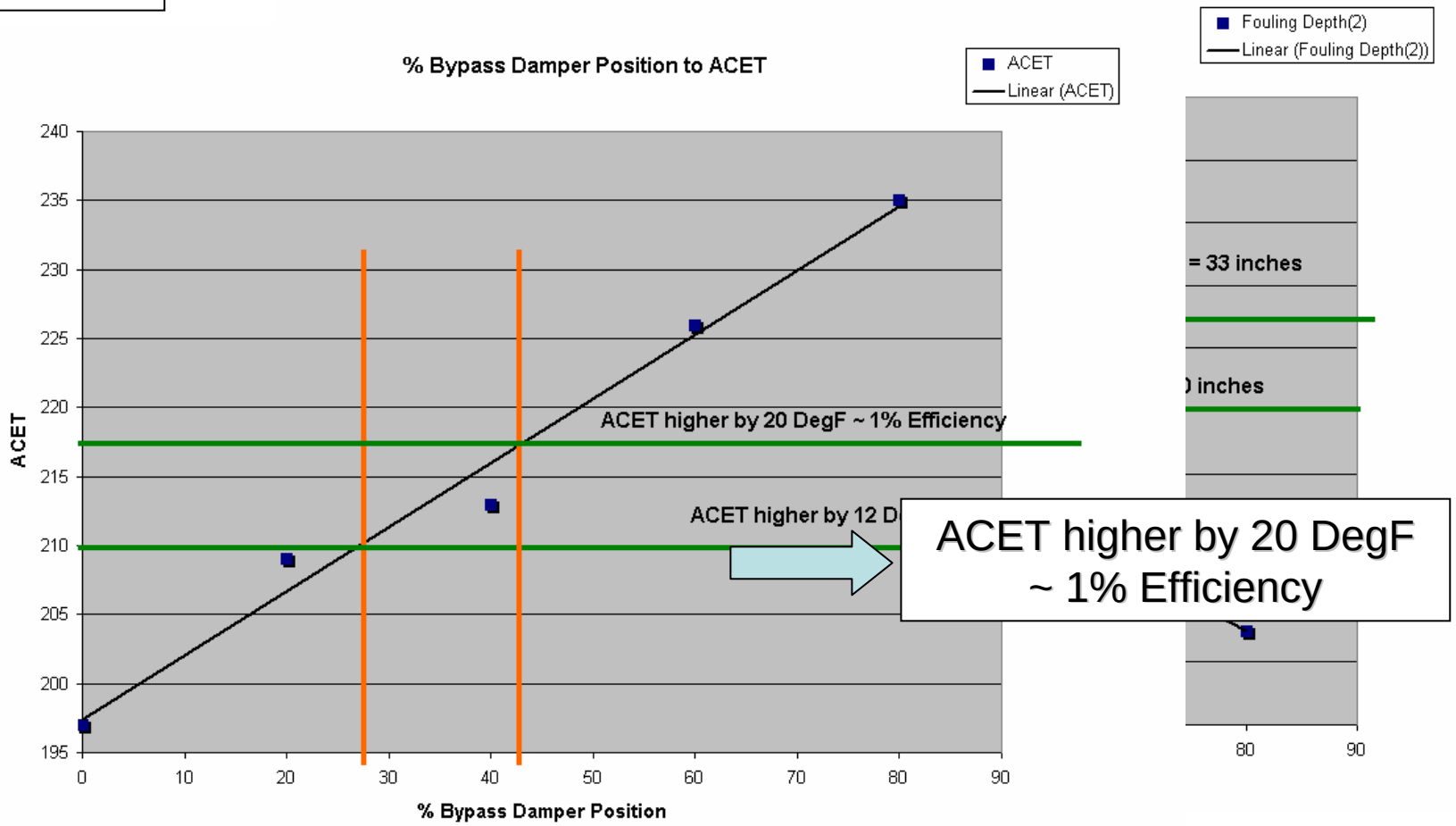
Air Heater Bypass Effects

Allowing the damper to 470F the temperature close to the boundary and improve Heat Rate by 0.5% and more!!

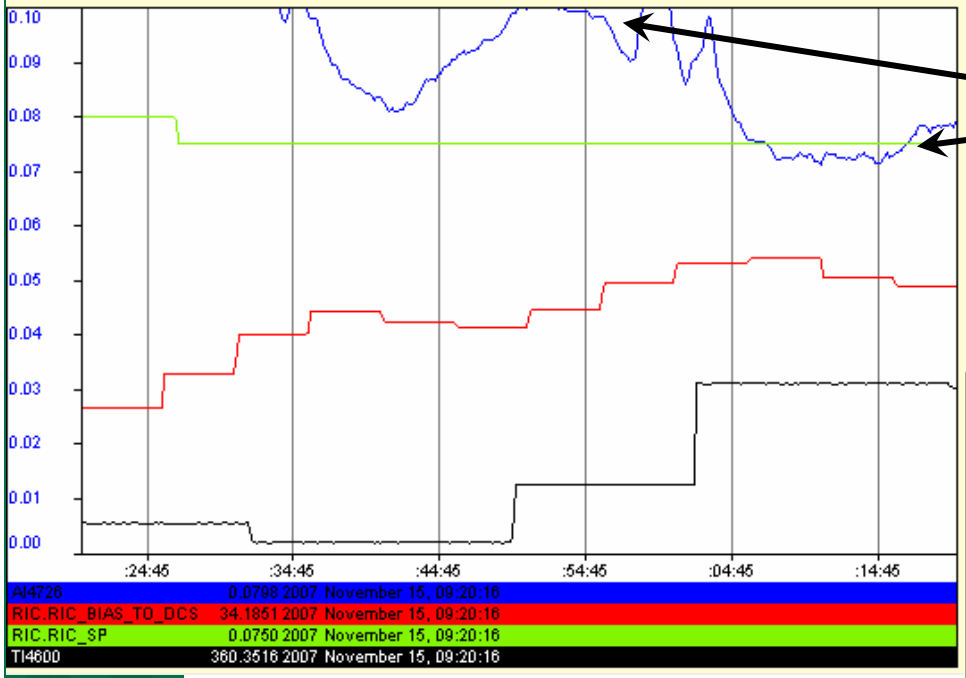
0.08 lb/MMBtu NOx SP

470 DegF T_{evap}



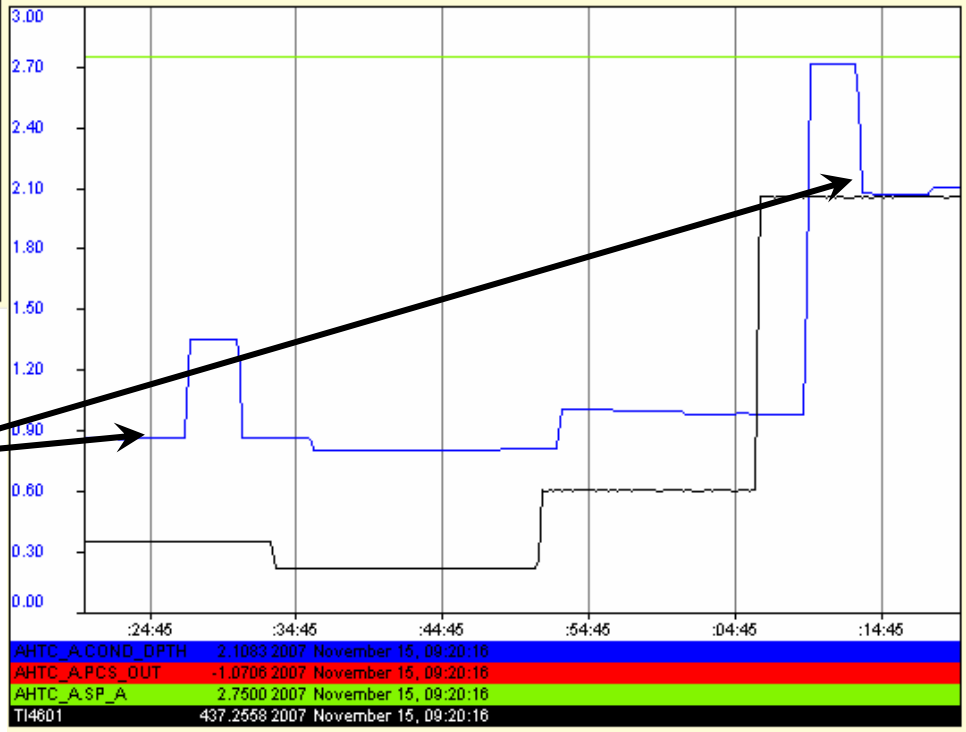
ACET higher by 20 DegF ~ 1% Efficiency

NOx-NH3 vs Depth Control Effects



NO_X goes from 0.1 lb/MMBtu to 0.075 lb/MMBtu

Cond. Depth goes from 0.8 feet to 2.4 feet



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When NH3/SO3 Control Isn't Enough

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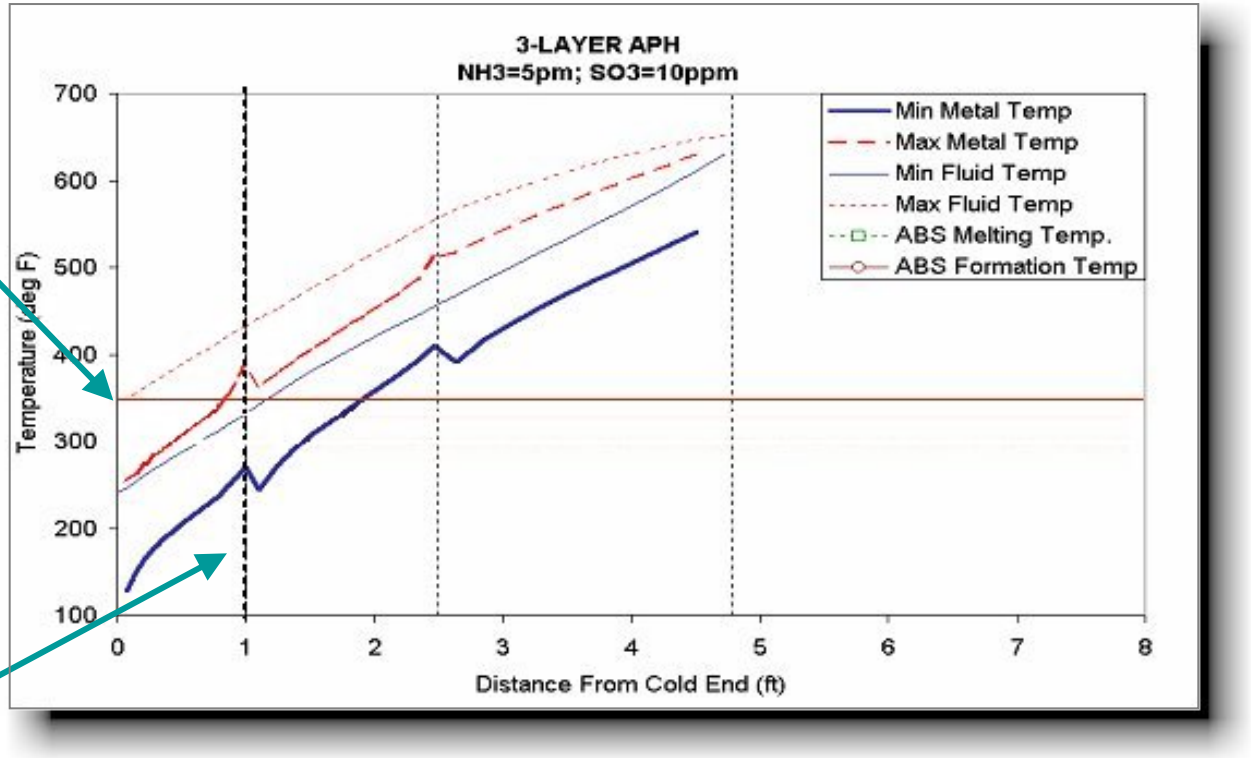
Remember This?

Evaporation Temperature

Cleanable Depth

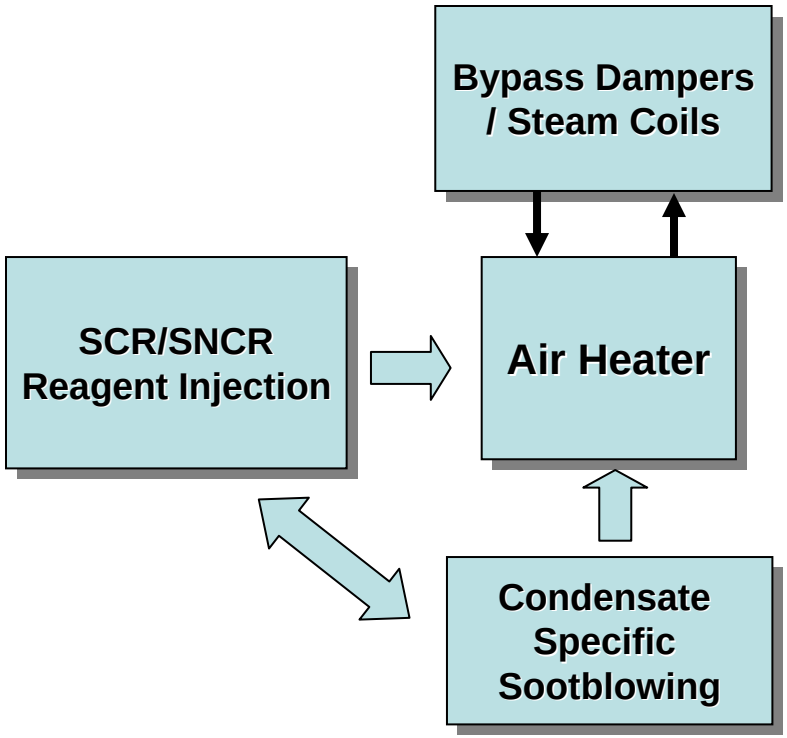


Air Heater Sootblowing

- **The AH Controller allows control of the NH_3 reagent based on effective cleanable depth**

- **If the cleanable depth were not a factor, more reagent could be employed and NOx could be lowered**

Integrated Reagent/AH Control



- **This aggressive sootblowing process, if overused, can lead to excessive air heater basket wear.**
- **Breen has developed a "smart" algorithm that integrates the total intensity of AbS formation and determines the exact time to execute the cleaning cycle**
- **Elimination of deposits means more NH_3 and more NOx reduction!!!!!**

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Conclusions

Conclusions

- **Breen now has over:**
  - **20 Full Scale Installation**
  - **5 Full Scale Installations using Closed Loop control**
  - **Demonstrations with every known SO3 mitigation technology**

Conclusions

- **Whether you are controlling:**
  - **NH3**
  - **SO3 Mitigation**
  - **Air Heater outlet temperature**

The end result is to maximize NOx reduction with fouling the air heater or compromising the ESP.

- **Additional steps to clean the air heater may be required.**

Thank You

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