Reinhold Environmental Ltd.

2010 NOx-Combustion Round Table & Expo Presentation

February 8 & 9, 2010 Chattanooga, TN

SO3 MITIGATION SYSTEM & PROCESS IMPROVEMENTS

Mark Thomas
Duke Energy

Jeff Wilson
Southern Company

Presentation Overview

- Basics/ Mitigation Fundamentals
- System Improvements
- Process Improvements
- BOP Issues
- Recent Developments & Testing
- Future Advancements

SO3 IMPACTS

NEGATIVE

- Plume Opacity
- Air Heater Pluggage
- Duct & Fan Corrosion
- Reduced Hg Capture
- Catalyst ABS
- SCR AIG Pluggage
- Baghouse Pluggage

POSITIVE

- ESP Conditioning

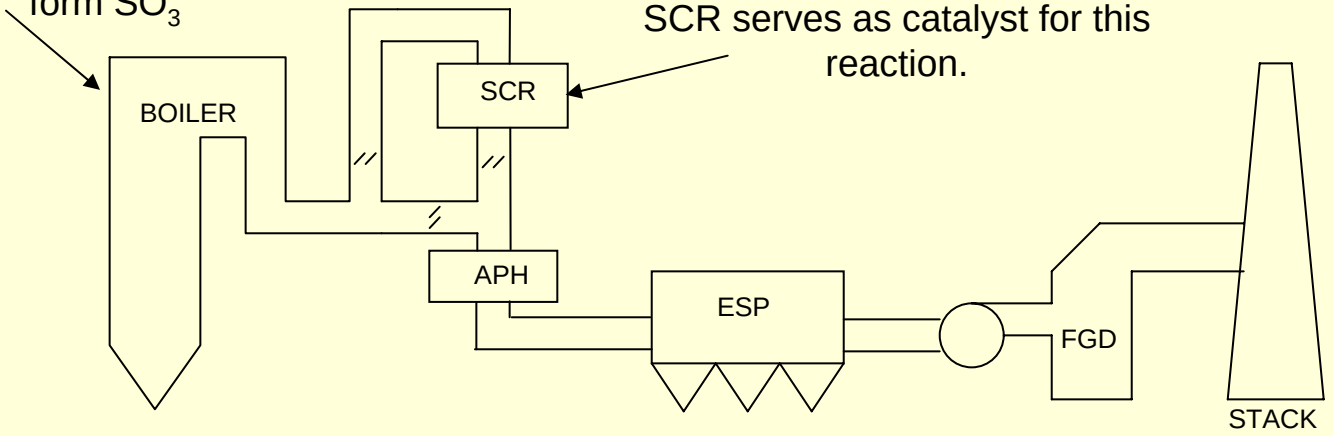
VISIBLE PLUME

- Opacity due to small quantities of H2SO4 (Sulfuric Acid) Aerosols in Flue Gas
- Aerosols produced from SO3 in flue gas when quenched in Absorber Mods

How SO_3 is Formed

In Boiler aprox 1% of SO_2 oxidizes to form SO_3

In SCR additional 0.75% -to-1.5% of SO_2 oxidizes to form $S0_3$. Vanadium in SCR serves as catalyst for this reaction.



Physical Forms of SO_3

Vaporous SO_3 Converts to Vaporous Sulfuric Acid (H_2SO_4)

$SO_{3Vap} + H_2O_{Vap} = H_2SO_{4Vap}$

Vaporous and Condensed Acid @ Temps Below Acid Dewpoint

Sulfuric Acid Mist (Aerosol) H_2SO_4

SO3 MITIGATION FUNDAMENTALS

Gas Phase Capture

- Molecular Gas Kinetics Drives Reaction with Sorbents
- Distribution of Sorbent Most Critical Requirement

Liquid Phase (Aerosol) Capture

- Aerosol Droplet Momentum & Static Charge Used to Capture

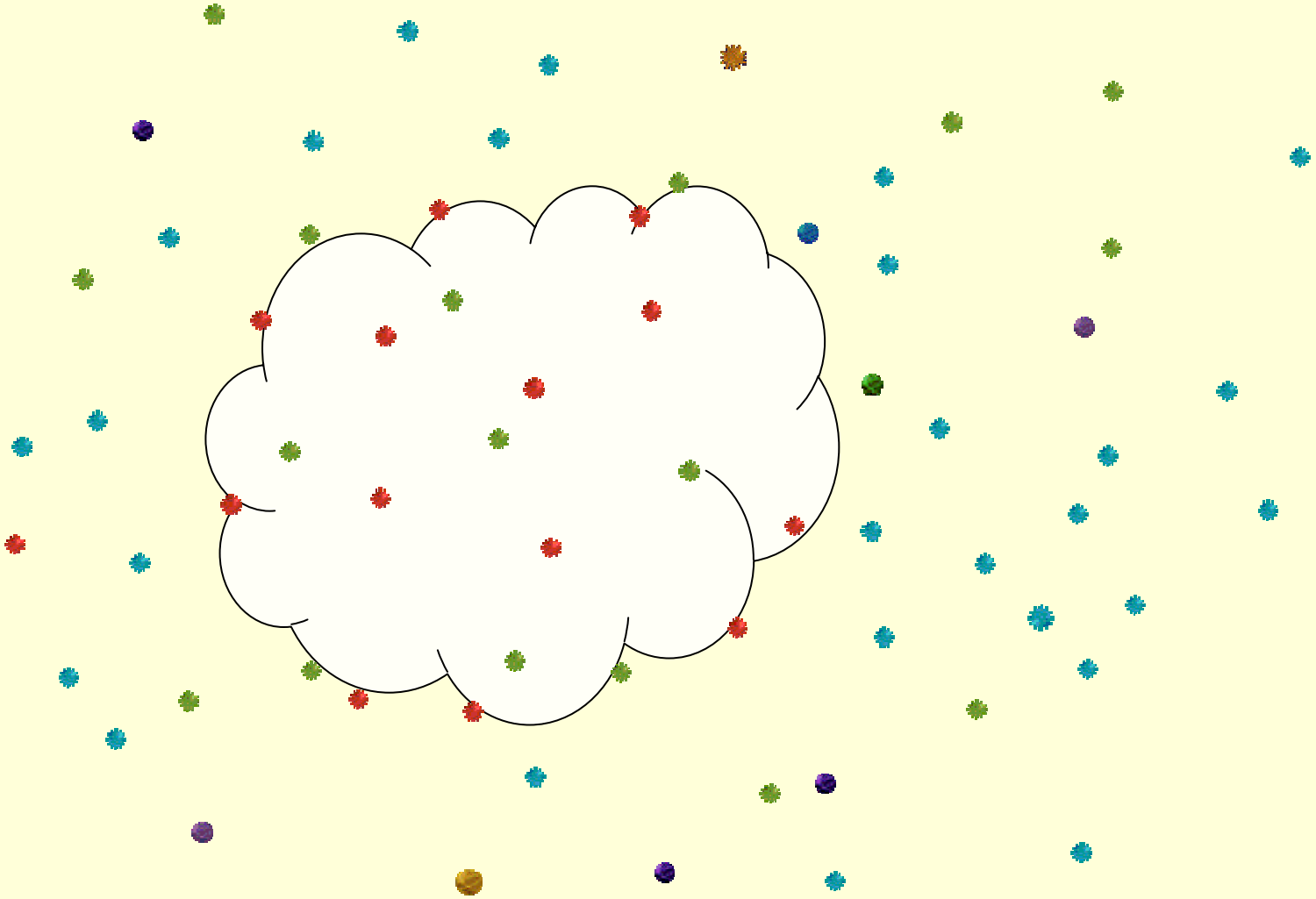
  Ex: WFGD, Wet Precips

  Condensation onto Particulate Matter

Inhibit Formation

- Reduce SCR Temps
- SCR Catalyst Formulation – Low Oxidation Catalyst
- Reduce SO2 ie Fuel Change

Gas Phase Capture - Illustrated



SO3 MITIGATION SORBENT OPTIONS

CALCIUM SORBENTS

- Hydrated Lime - Dry $Ca(OH)_2$
- Quick Lime - Dry CaO
- Limestone -Dry $CaCO_3$

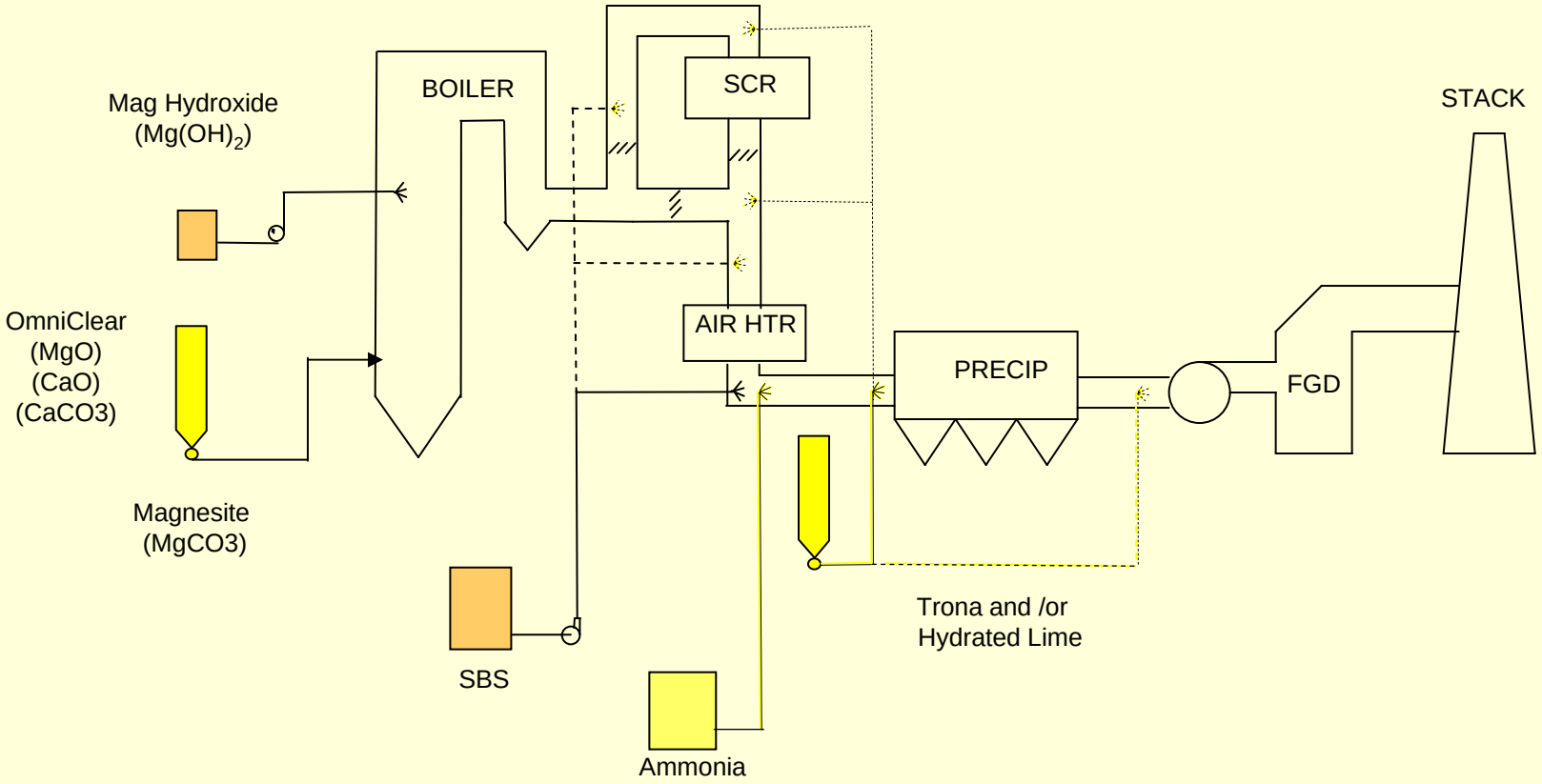
SODIUM SORBENTS

- SBS Soda Ash - Wet Na_2CO_3
- Trona - Dry $Na_2CO_3+NaHCO_3+2H_2O$
- Sodium BiCarbonate $NaHCO_3$

MAGNESIUM SORBENTS

- Magnesium Hyrdoxide – Wet $Mg(OH)_2$
- Magnesium Oxide – Dry MgO
- Magnesite (Mag Carbonate) – Dry $MgCO_3$

SO_3 MITIGATION STRATEGIES



System Problems

Dry System Issues

- Poor Distribution
- Feed Interruptions
- Lance Pluggage
- Piping Scaling
- Duct Deposits
- Reagent Quality
- Reagent Storage & Handling

Wet System Issues

- Duct Deposits
- Lance Deposits
- Lance Corrosion
- Nozzle Pluggage (Slurries)

SO3 Mitigation System Improvements

Wet System Improvements

- Lance Redesign
- Pump Upgrades
- Vendor R&D Ongoing

Dry System Improvements

- Better Reagent Distrib & Mixing
  - More Lances
  - Dispersion Plates
- Trona Milling On Site
- Better Fluidization in Silo
- Reduced Lance Pluggage
- Sight Glasses
- Powder Flow Meters
- Simplification

SO3 Mitigation System Improvements

Significant Improvements with Hydrated Lime Systems

- R&D Efforts Seeing Results
- Jeff Wilson Southern Co Presentation

Improved Mitigation Process Understanding

- SO3 Formation Modeling (EPRI)
  - Furnace Oxidation Factors Better Understood
- Dispersion Modeling vs Field Inspections
  - Dispersion improvements often have a greater potential to improve performance than reagent particle size reduction or surface area increases
- Reaction Kinetics
  - Help better understand competing reactions and order of reactions
  - Better understanding of true reagent utilization
- Testing has revealed much about SO3 related condensables
  - May be critical to resolving APH pluggage issue

Lessons from Mitigation Trials

- Make sure you know your objectives
  - Determine critical information prior test campaign
  - Design Test campaign to focus on critical info primarily
    - Multi Million Dollar Decisions can be made using incomplete data
- Test Data from different Units often not interchangeable
  - Scrutinize assumptions carefully
  - Be careful not to credit potential benefits which could be achieved in another manner.
    - Ex: APH Pluggage reduction
  - Be careful not to assume issues/ effects in past will be same now
- Include all significant Impacts in Cost/Benefit Analysis

SO3 Mitigation Process Advancement

- Progress from SO3 Focus to Co-Benefits Analysis
- Integrated Environmental Control / BOP Analysis
  - Corrosion
  - APH Pluggage
  - SCR Turndown
  - Baghouse Protection
  - HAPs/ HCl/Hf effects on FGD
  - Arsenic Mitigation/ Catalyst Protection
  - Potential SCR Catalyst Degradation
  - Furnace Slagging
  - Plume Opacity

Potential Co-Benefit Examples

#1 Fuel Flexibility -Increased Chlorine Content

Using Pre SCR or Pre APH SO3/ HCl Mitigation

- Increased HCl Removal Protects FGD from Hi Chlorine
  - May avoid installation of WW treat system ($20M-$50M)
- Boiler Chlorine limits can be increased somewhat
  - Reduced Deep Staging to Increase Blr NOx
  - Incrs SCR NOx Removal & Slip w/o APH Pluggage

Potential Co-Benefit Example

#2 Avoid Stack Replacement with WFGD Addition

- Stacks replaced due to wet gas from WFGD
- Low SO3 Levels @ FGD Inlet could permit the use of Gas-Gas Reheaters to reheat FGD exit gas
- Would also result in cooler FGD gas inlet temps and less evaporation
- New wet stacks are ~$60M - $80M

SO3 Mitigation Path Forward

- Unresolved Issues Require Testing
  - Prove SO3 reduction required to avoid APH pluggage
  - Catalyst Poisoning from Pre SCR Injection
  - HCl/ Hf/ HAPs removal vs SO3 removal
  - Hg Ox impacts from Pre SCR HCl removal
  - Long Term Milling effectiveness and reliability
  - Continue to reduce Lime scaling