REINHOLD ENVIRONMENTAL Ltd.

2010 APC Round Table
& Expo Presentation

July 18-20, 2010, in Concord, NC / Hosted by Duke Energy

SO3 MITIGATION SYSTEMS
RECENT EXPERIENCE

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Presentation Overview

- Interactive Discussion
  - Shared Experiences
    - General Info, Specifc where possible
- Basics/ Mitigation Fundamentals
- BOP Issues
- Recent Experience
- Future Advancements

SO3 IMPACTS

NEGATIVE

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

POSITIVE

- ESP Conditioning

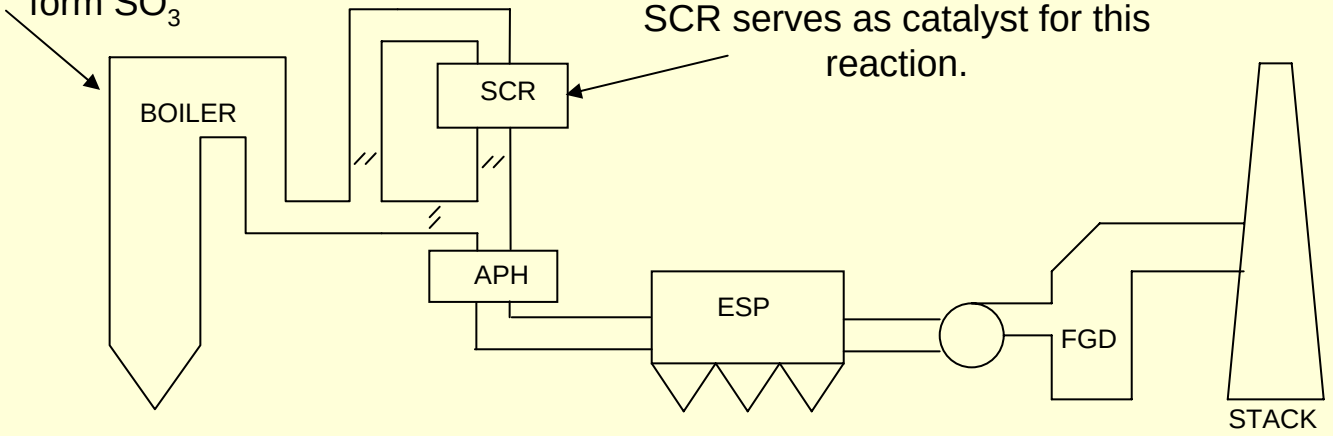
VISIBLE PLUME

- 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, WESP
- Condensation onto Particulate Matter

Inhibit Formation

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

SO3 MITIGATION SORBENT OPTIONS

CALCIUM SORBENTS

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

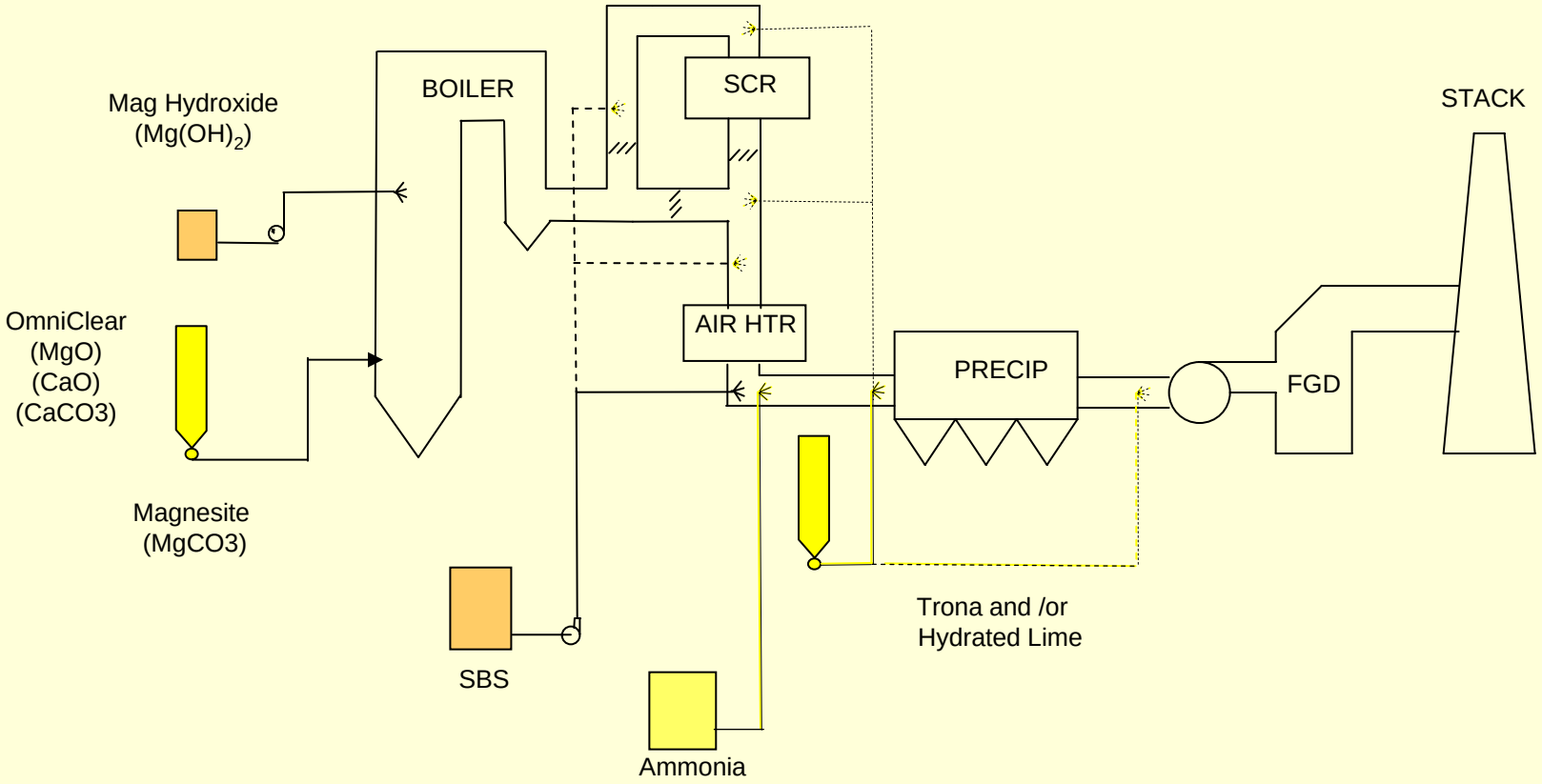
SODIUM SORBENTS

- 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 Issues

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 - Recent Experience

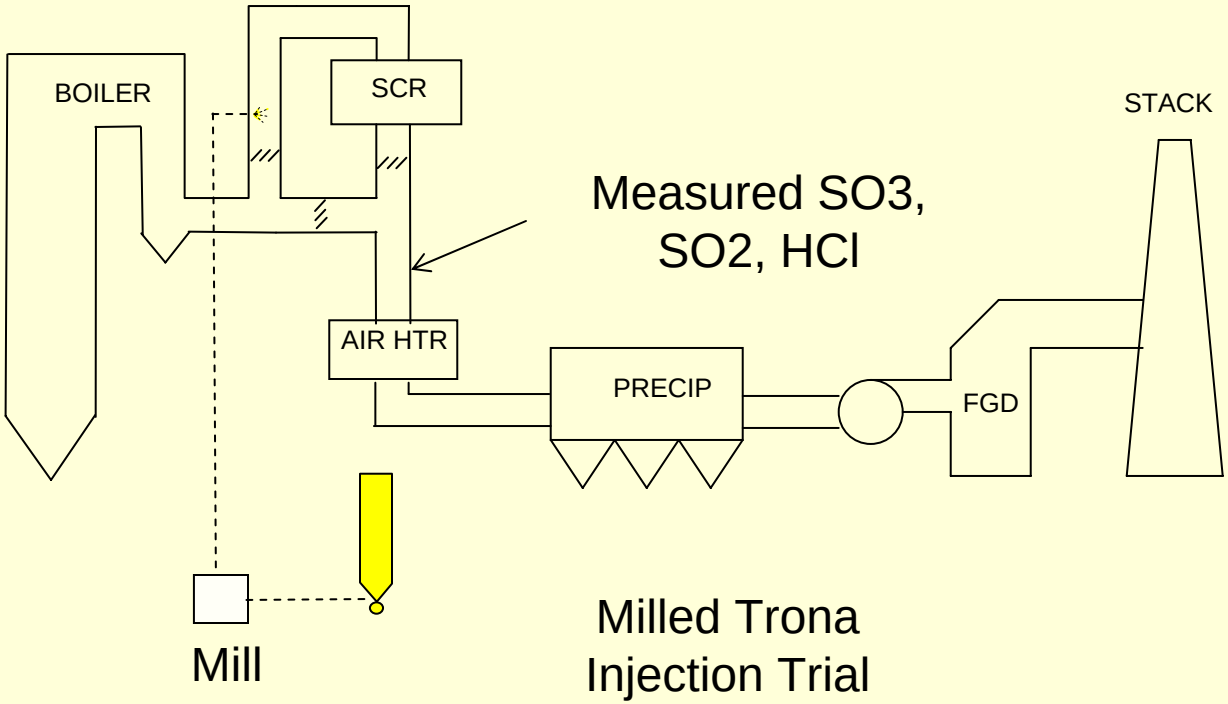
- Duke Experience – Last 12 Months
  - Hydrated Lime
    - Pre-SCR Hydrated Lime Injection Trial
  - Trona
    - Pre-SCR Milled Trona Injection Trial
    - Milled Trona Trials (for SO2)
  - SBS
    - Pre-SCR SBS Injection – Extended Trial
  - Magnesium Hydroxide – Furncae Injection
  - Magnesite – Coal Additive
- Southern Company Recent Experience
  - New Trona System
- Others

Duke Energy - Recent SO3 Mitigation Experience

Pre-SCR Trona Injection Trial – Fall 2009

- 1300 Mw Unit
  - SCR – ESP – WFGD (Thiosorbic Lime)
- Milled Trona Injected at Econ Outlet
- Measured SO3 & HCl @ APH Inlet
- Objective
  - Prove incrs SO3 removal w/ incrs residence time
  - Prove increased efficiency with milled Trona
    - D50 ~30-40um >>>D50 12-15um

Duke Energy - Recent SO3 Mitigation Experience



Duke Energy - Recent SO3 Mitigation Experience

Pre-SCR Trona Injection Trial – Findings

- Low levels of SO3 can be achieved <5ppm @APH Inlet
  - Required higher injection rates than expected
    - Loss to SO2 Possible Reason
  - Able to eliminate condensables
- 15-40% HCl removal @ APH Inlet
- Mill cleaning daily required
- Effect on Catalyst Uncertrain (Likely not good)
- Effect on Catalyst Hg Oxidation uncertain

Duke Energy - Recent SO3 Mitigation Experience

Pre-SCR Hydrated Lime Injection Trial – Findings

- Low levels of SO3 can be achieved <5ppm @APH Inlet
  - Required higher injection rates than expected
    - Loss to CO2 Possible Reason
  - Able to eliminate condensables
- 40-65% HCl removal @ APH Inlet
- Effect on SCR Catalyst Uncertain
- Effect on Catalyst Hg Oxidation Uncertain

Duke Energy - Recent SO3 Mitigation Experience

Pre-SCR SBS Injection

- Injected SBS/Soda Ash continuously ahead of B-Side SCR
- Objectives
  - Eliminate APH Pluggage
  - Eliminate ESP Perf Plate and Duct Deposits

Duke Energy - Recent SO3 Mitigation Experience

Pre-SCR SBS Injection - Findings

- Able to achieve Ultra Low SO3 levels
- Able to eliminate Condensables
- Required Higher than expected feedrates
  - SO2?
  - Sodium maldistribution?
- ESP increased Opacity due to low SO3
- Apparent increased SCR Catalyst Deactivation

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 /Multi Pollutant Focus
- 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

SO3 Mitigation Path Forward

- Unresolved Issues Require Testing
  - Prove SO3 reduction required to avoid APH pluggage
  - Catalyst Poisoning from Pre SCR Reagent Injection
    - Requires cost/ benefit analysis
  - 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

SO3 Mitigation – Recent Experience

- Southern Co. - TronSystem
- Others

SO3 Mitigation – Recent Experience

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QUESTIONS??