# REINHOLD ENVIRONMENTAL Ltd.


# 2011 APC Round Table
# & Expo Presentation

July 11-12, 2011, in Cleveland, OH / Hosted by FirstEnergy

# Controlling HCl and $SO_3$ Emissions for U-MACT (equipment & sorbents)

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**2011 Air Pollution Control Round Table**

**Cleveland, Ohio – July 12, 2011**

NOL-TEC SYSTEMS

SORB-N-JECT® Technology

Lodge Cottrell

# Agenda

- Why
  - **Why** DSI for HCl and $SO_3$ removal (U-MACT)
- What
  - **What** is Dry Sorbent Injection (equipment)
- How
  - **How** to achieve U-MACT limits (sorbents)

# **Why** Dry Sorbent Injection?

- EGU-MACT
- Technologies
- Considerations
- EPA's Comments
- The Net

- What does the U-MACT state?
- Various Technologies
- Which Technology?
- EPA's Comments
- The Net

# EGU-MACT

- EGU-MACT
- Technologies
- Considerations
- EPA's Comments
- The Net

*"Electric Generating Unit – Max. Achievable Control Tech."*

Big Picture

- EGU-MACT: Amendment to CAA Section 112
- 1970: President Nixon signed Clean Air Act
- 1977: Clean Air Act Amendments address $SO_2$ (NAAQS)
- 1990: President Bush signed amendment focusing on $NO_x$

Past 10 Years

- 2000: EPA adds EGU's to source – 112(c)
- 2005: EPA vacates 2000 decision
- 2008: US Court of Appeals rules against EPA

# EGU-MACT

- EGU-MACT
- Technologies
- Considerations
- EPA's Comments
- The Net

## 2008 Consent Decree Effects

•Under Section 112(c) Coal and Oil fired EGU's are to be on the source list

•Under Section 112(d) NESHAP for Coal and Oil fired to reflect "MACT" consistent with 112(d) #2 (Standards and Methods) and #3 (New and Existing Sources)

•EPA must sign into law a final rule by November 16, 2011

## Time Frame

•3 Years to comply after final rule

# EGU-MACT

- EGU-MACT
- Technologies
- Considerations
- EPA's Comments
- The Net

## Affected Units

- EPA estimates 1,350 Units across 525 power plant sites
- Half of EGU's do not have advanced APC equipment

## Pollutants

- Mercury – Targeting an overall 78% reduction
- HCl – Surrogate for acid gases; targeting an overall 91% reduction; targeting an overall 55% reduction of $SO_2$
- PM – Surrogate for non-Mercury metals

## HCl Limit for existing Units

- 0.0020 $^{lbs}/_{MMBtu}$

# EGU-MACT



What about $SO_3$

- No specific limit mentioned in EGU-MACT
- EPA mentions $SO_3$ when discussing Hg
- Also, mentioned when discussing condensable PM
- DSI for HCl is a surrogate for $SO_3$ removal
- In addition to EGU-MACT, state limits/rules address $SO_3$
- Lastly, $SO_3$ is a visible PR issue

# Technologies



Wet FGD

- Utilizes a slurry of alkaline sorbent; usually limestone
- Flue gas is sprayed or is forced through a pool of slurry
- Goal is high contact between water, calcium, and acid gas
- Massive system – large budget and longer schedule

Dry FGD ("Semi-Dry")

- Usually applied for $SO_2$ removal
- HCl applications primarily in waste incineration market
- Calcium based; high sorbent utilization
- Temperature manipulation to control humidity

# Technologies



Dry Sorbent Injection

- No water – it's dry!
- Injection directly into duct
- Need well-placed lance locations
- Location: SCR outlet; APH outlet; ESP outlet (w/ wFGD)
- Sorbents: Sodium or Calcium
- Dilute phase system (silos, blowers, convey line, etc.)

# Which Technology for HCl Removal?

- EGU-MACT
- Technologies
- Considerations
- EPA's Comments
- The Net

HCl Levels

- Depends on coal and system loading
- Amount of HCl impacts viable technology
- High HCl may result in "unreasonable" sorbent rates w/ DSI

$SO_2$ Control?

- Is $SO_2$ being regulated? If so, HCl may be in compliance

Ash

- Ash sales may prevent the use of sodium
- Disposal costs

# Which Technology for HCl Removal?

- EGU-MACT
- Technologies
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Particulate Control Device

•ESP or FF

•Existing PCD capacity

Cost

•Capital Costs versus Operating Costs

•Three technologies vary greatly

•Life Cycle: How long is APC equipment in operation?

•Lowest overall cost?  It's complicated

Schedule

•1-Year or 3-Years?

# EPA's Comments



HCl Removal

- Existing FGD's will capture HCl, HF, and HCN
- DSI has also been shown to capture these acid gases

"Good" Candidates for DSI

- "Smaller" coal-fired units
- Low-Sulfur Coal
- Units that do not operate in a base-load mode

Summary

- "EPA does not project use of wet scrubbing technology to meet the requirements of this proposed rule."

# The Net



Why DSI for HCl & $SO_3$

- Low capital cost solution
- Effective for HCl & $SO_3$ removal
- Quick installation and start up

The Net: Dry Sorbent Injection…

- …is not the perfect solution for every application
- …will be used by many to achieve HCl emission limits
- …is the right choice for $SO_3$

# **What** is Dry Sorbent Injection?

*"Operating Experiences & Lessons Learned"*

- Definition
- Schematic
- Equipment
- Portable
- Permanent

- Definition
- Schematic
- Equipment
- Portable Test System
- Permanent System

# **What** is Dry Sorbent Injection?

- Definition
- Schematic
- Equipment
- Portable
- Permanent

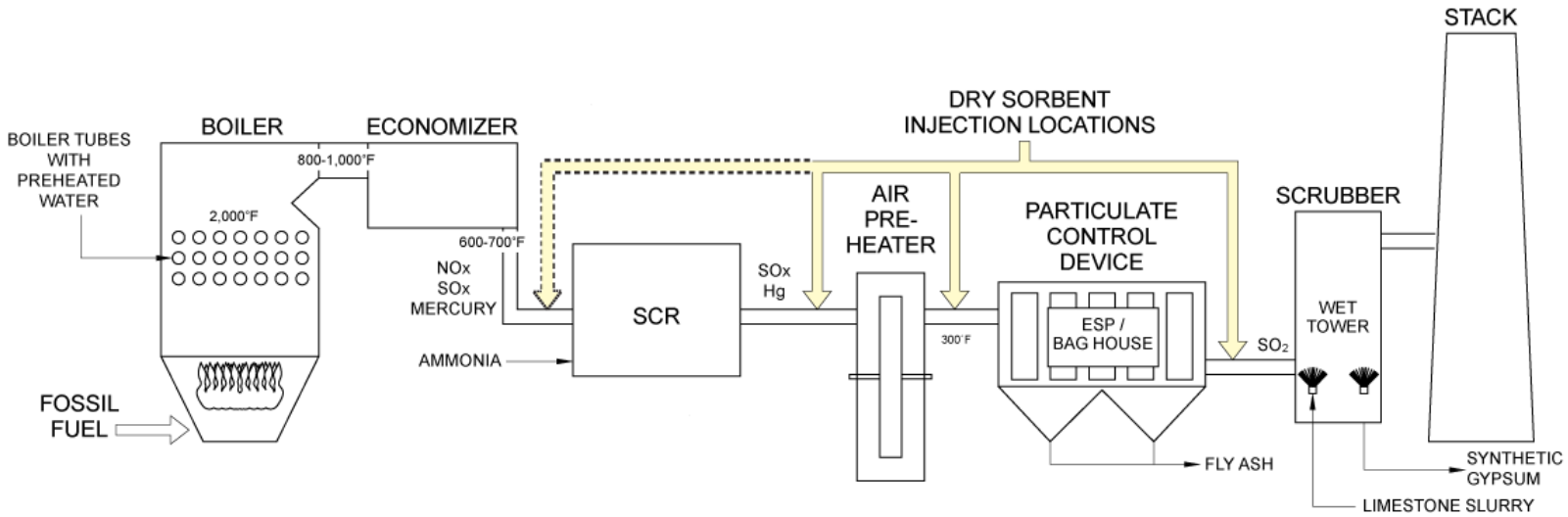
*Injecting selected dry sorbents into ductwork leaving the boiler.*

Controlling HCl and $SO_3$ Emissions for U-MACT

Why | What | How

# Schematic

- Definition
- Schematic
- Equipment
- Portable
- Permanent

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Controlling HCl and $SO_3$ Emissions for U-MACT

Why | What | How

# Schematic

- Definition
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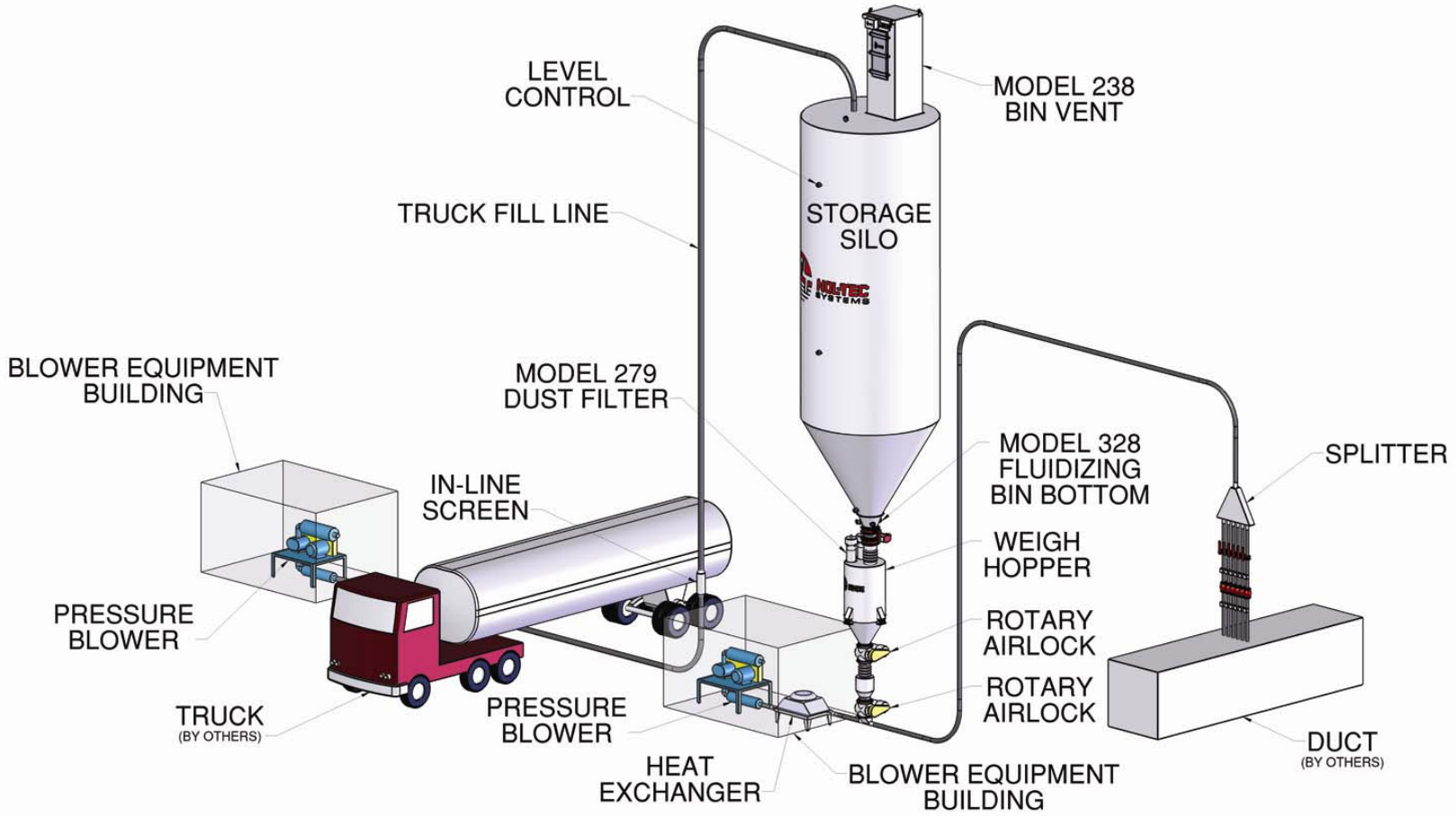


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# Truck/Rail Unload

- Definition
- Schematic
- Equipment
- Portable
- Permanent

Controlling HCl and $SO_3$ Emissions for U-MACT

Why | What | How

# Storage

- Definition
- Schematic
- Equipment
- Portable
- Permanent

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Controlling HCl and $SO_3$ Emissions for U-MACT

Why | What | How

# Dust Collection

- Definition
- Schematic
- Equipment
- Portable
- Permanent


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Controlling HCl and $SO_3$ Emissions for U-MACT

Why | What | How

# Silo Discharge Aeration

- Definition
- Schematic
- Equipment
- Portable
- Permanent

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Controlling HCl and $SO_3$ Emissions for U-MACT

Why | What | How

# Silo Discharge

- Definition
- Schematic
- Equipment
- Portable
- Permanent


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Controlling HCl and $SO_3$ Emissions for U-MACT

Why | What | How

# L-I-W Feeders

- Definition
- Schematic
- Equipment
- Portable
- Permanent

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# Compressor

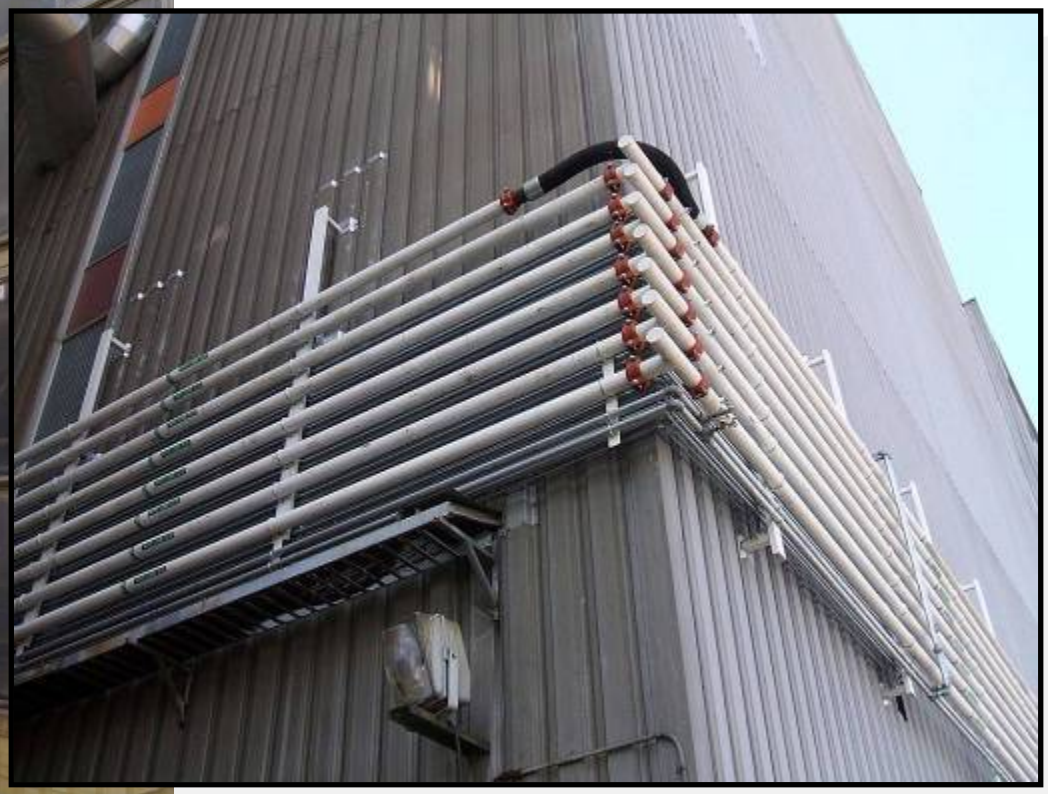
- Definition
- Schematic
- Equipment
- Portable
- Permanent

# Positive Displacement Blower

- Definition
- Schematic
- Equipment
- Portable
- Permanent

# Convey Lines

- Definition
- Schematic
- Equipment
- Portable
- Permanent

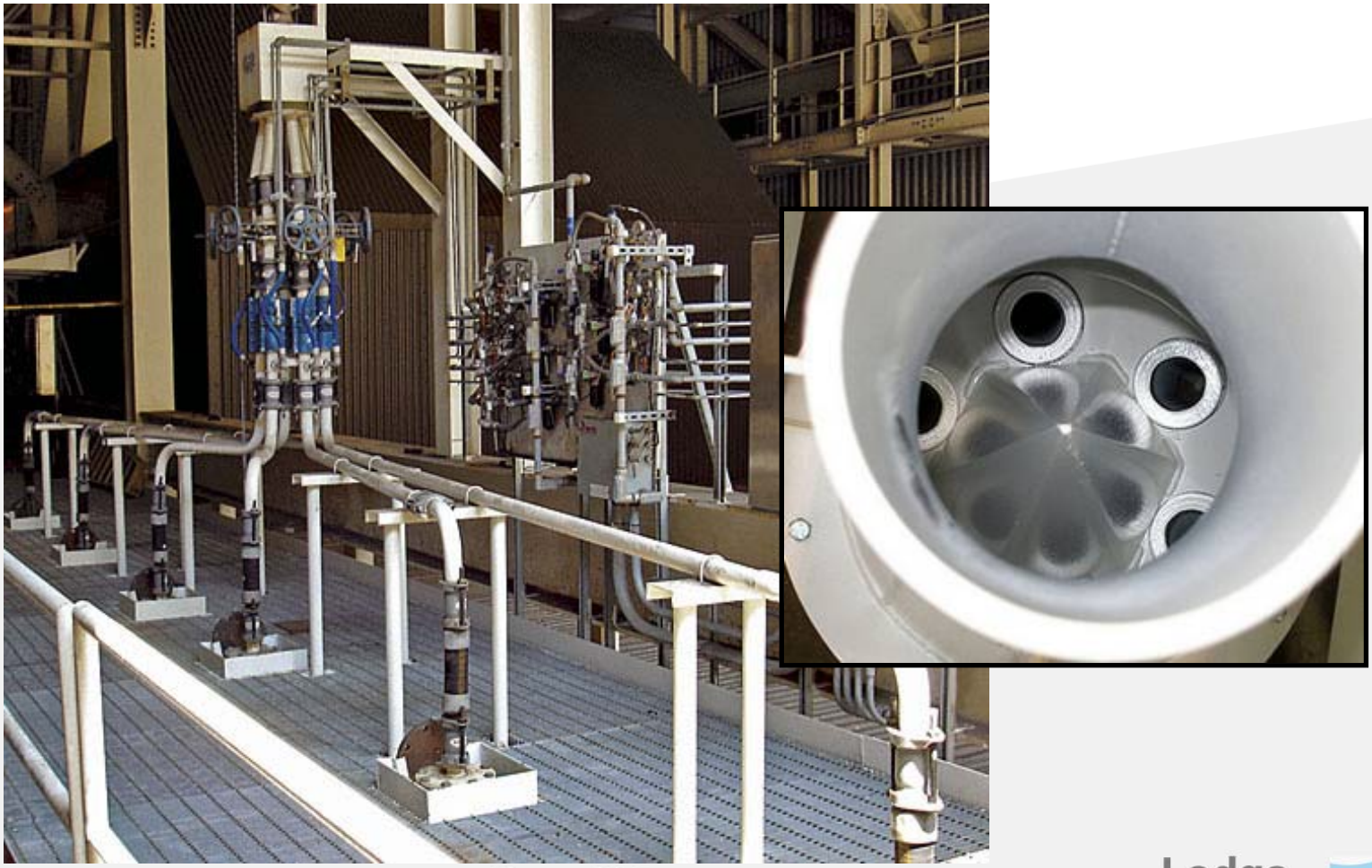


Controlling HCl and $SO_3$ Emissions for U-MACT

Why | What | How

# Splitters

- Definition
- Schematic
- Equipment
- Portable
- Permanent



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# Injection Point

- Definition
- Schematic
- Equipment
- Portable
- Permanent

Controlling HCl and $SO_3$ Emissions for U-MACT

Why | What | How

# Control Room

- Definition
- Schematic
- Equipment
- Portable
- Permanent

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Controlling HCl and $SO_3$ Emissions for U-MACT

Why | What | How

# Portable System

- Definition
- Schematic
- Equipment
- Portable
- Permanent




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Controlling HCl and $SO_3$ Emissions for U-MACT

Why | What | How

# Portable System

- Definition
- Schematic
- Equipment
- Portable


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# Portable System

- Definition
- Schematic
- Equipment
- Portable
- Permanent

# Permanent System

- Definition
- Schematic
- Equipment
- Portable
- Permanent

Typical Components

- Truck/Rail Unload
- Storage
- Dust Collection
- Silo Discharge Assist
- L-I-W Feeders
- Dryers
- Blowers
- Heat Exchangers
- Convey Lines
- Splitters
- Injection Lances
- Electrical Control

# Permanent System

- Definition
- Schematic
- Equipment
- Portable
- Permanent

Optional Components

- Remote Unloading
- Milling Equipment
- Degree of Redundancy
- Degree of storage based on “Days of Storage” in spec.
- DCS or PLC
- Dehumidifiers
- CFD Modeling

# **How** to achieve U-MACT limits (sorbents)

- Parameters
- Calcium
- Sodium
- Overlap
- Scenarios

- Factors governing removal efficiencies
- Calcium (Hydrated Lime)
- Sodium (Trona & Sodium Bicarbonate)
- Overlap: Competing Reactions
- Scenarios

# Parameters Impacting HAP Removal

- Parameters
- Calcium
- Sodium
- Overlap
- Scenarios

Factors that Impact Removal Efficiency

- Quantity and Quality of Sorbent
- Coverage of Duct (CFD Modeling)
- Temperature
- Mixing
- Residence Time (>1 sec)
- ESP/PJFF

# Calcium Sorbents

- Parameters
- Calcium
- Sodium
- Overlap
- Scenarios

Calcium (Hydrated Lime)

- $Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$

Application: Rules of Thumb

- More moisture in flue gas the better
- Level of removal dependent on “quality” of lime
- When mitigating $SO_3$ Hydrated Lime can be mitigated at lower temperatures and still achieve high levels of removal

# Sodium Sorbents

- Parameters
- Calcium
- Sodium
- Overlap
- Scenarios

Sodium (Trona / Sodium Bicarbonate)

•Calcination Step:

$2(Na_2CO_3 \bullet NaHCO_3 \bullet 2H_2O) + \text{heat} \rightarrow 3Na_2CO_3 + 5H_2O + CO_2$

$2\ NaHCO_3 + \text{heat} \rightarrow Na_2CO_3 + H_2O + CO_2$

•Reaction Step: $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

Application: Rules of Thumb

•Hot temperatures are better

# Overlap: Competing Reactions



Order of Preferential Reactions

- $SO_3$ → HCl → $SO_2$

Overlap: Rules of Thumb

- When injecting sorbent, which pollutant reacts first?
- When targeting 80%+ removal of $SO_3$ assume 20%-30% removal of HCl
- When targeting 80%+ removal of HCl assume 95%+ removal of $SO_3$ and 20%-40% removal of $SO_2$

# Scenario 1

- Parameters
- Calcium
- Sodium
- Overlap
- Scenarios

Plant Configuration

- Coal: Low Sulfur, Low Chlorine (i.e. Sub-Bituminous)
- Chlorine: 20-100 ppm
- $SO_2$: 0.5-1.0 $^{lb}/_{MMBtu}$
- Boiler → APH → ESP

Technology Strategy

- Use Dry Sorbent Injection for HCl
- Low Capital Cost
- Low Sorbent Cost

# Scenario 2

- Parameters
- Calcium
- Sodium
- Overlap
- Scenarios

Plant Configuration

- Coal: High Sulfur, High Chlorine (i.e. E-Bituminous)
- Chlorine: 1,000-1,300 ppm
- $SO_2$: 4.0-5.0 $^{lb}/_{MMBtu}$
- Boiler → APH → ESP

Technology Strategy

- DSI is low capital cost but sorbent rates are high
- Consider adding PJFF to improve NSR
- Consider dry FGD, GSA, or wet FGD

# Scenario 3

- Parameters
- Calcium
- Sodium
- Overlap
- Scenarios

Plant Configuration

- Coal: High Sulfur, High Chlorine (i.e. E-Bituminous)
- Chlorine: 1,000-1,300 ppm
- $SO_2$: 4.0-5.0 $^{lb}/_{MMBtu}$
- Boiler → SCR → APH → ESP

Technology Strategy

- DSI needed for $SO_3$ removal
- Consider adding PJFF to improve NSR
- Consider dry FGD, GSA, or wet FGD

# Scenario 4

- Parameters
- Calcium
- Sodium
- Overlap
- Scenarios

Plant Configuration

- Coal: High Sulfur, High Chlorine (i.e. E-Bituminous)
- Chlorine: 1,000-1,300 ppm
- $SO_2$: 4.0-5.0 $^{lb}/_{MMBtu}$
- Boiler → SCR → APH → ESP → wFGD

Technology Strategy

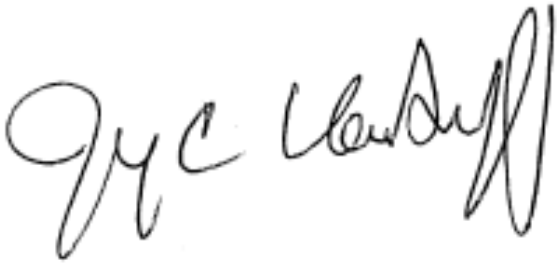
- DSI needed for $SO_3$ removal
- HCl and $SO_2$ captured in wet FGD
- If wet FGD cannot make HCl EGU-MACT use DSI to help

# Closing

Why
- DSI a good option to attain HCl limits in EGU-MACT

What
- Dry Sorbent Injection is a low capital cost option

How
- Hydrated Lime, Trona, and SBC available sorbents



# Thank You!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