Calcium Hydroxide DSI and Factors that Impact Acid Gas Control Performance – for MARAMA
Agenda

- History of calcium DSI
- Factors that impact effectiveness
- Data on utility HCl control with calcium hydroxide
- Ancillary impacts of calcium hydroxide DSI
- Summary and next steps for technology development
History of Calcium DSI

- LIMB project – hydrated lime injection
  - Major R&D project from 1988 – 1992
  - Demonstrated SO₂ control capability of approx. 50%-60%
  - Too low to compete with FGD scrubbers

- LNA pioneered use of calcium DSI for utility SO₃ control at TVA Widows Creek in 2004
  - Much more effective for aggressive acid gases (SO₃, HCl, HF)
  - Demonstrated control capability in excess of 95%
  - Calcium DSI now in use at well over 25 utility units

- Data on use of hydrated lime for HCl control comes from European experience
  - Demonstrated to capture over 95% of HCl in MSW acid gas control applications
  - Limited data on utility HCl control
  - Pilot combustor work to date indicates HCl MACT emission levels achievable for most facilities
  - Effectiveness impacted by many factors
## Calcium hydroxide – HCl Reaction Process

<table>
<thead>
<tr>
<th>Step</th>
<th>Reagents</th>
<th>Reaction</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>First step</td>
<td>Ca(OH)₂ + HCl</td>
<td>→</td>
<td>CaClOH + H₂O</td>
</tr>
<tr>
<td>Molar mass (g/mol⁻¹)</td>
<td>74.1 36.5</td>
<td>Very Fast</td>
<td>92.5 18.0</td>
</tr>
</tbody>
</table>

| Second step    | CaClOH + HCl  | →          | CaCl₂ + H₂O    |
| Molar mass (g/mol⁻¹) | 92.5 36.5 | Slow      | 111.0 18.0 |
Calcium DSI Effectiveness Factors

- Flue Gas Properties
  - Temperature
  - Flue gas moisture
  - Other competing acid gases (SO₃, HF and SO₂)

- Reagent Properties – physical and chemical
  - Relative reagent reactivity
  - Reagent surface area
  - Reagent porosity

- Injection System Configuration
  - Particulate control device
  - In flight residence time
  - Reagent mixing
  - Injection location
Impact of competing acid gases

- HCl
- SO₃
- SO₂

% Control vs. Temperature
Reagent Properties - Calcium Hydroxide for AGC Applications

- Standard Hydrated lime
- Sorbacal® H
- Sorbacal® SP
Reagent Properties - Sorbacal® Products

- **Standard Hydrate**
  - SSA 15 - 18 m²/g (BET)

- **Sorbacal® H**
  - SSA 17 - 22 m²/g (BET)

- **Sorbacal® SP**
  - High SSA > 40 m²/g (BET)
  - Large Pore Volume

- **Sorbacal® SPS**
  - Activated Sorbacal® SP to improve its SOx removal performances
SYSTEM CONFIGURATION

Ca(OH)₂
**HCI CAPTURE EFFICIENCY**

![Graph showing capture efficiency vs. stoichiometric ratio]

- **Capture efficiency (%)**
- **Stoichiometric ratio**

- **Sorbacal® SP**
- **Ca(OH)₂ std.**
HCl Emission Levels
With Ca(OH)2 Injection

- Inlet HCl concentration of 200 ppm
- Inlet HCl concentration of 44 ppm

Stnd Hydrate
Sorbacal SPS

MACT HCl limit

Inlet HCl concentration of 44 ppm
Inlet HCl concentration of 200 ppm

Global SR

HCl emissions (lb/MM Btu)
Other Impacts of Hydrated Lime DSI

- **Mercury (Hg):**
  - Since $\text{SO}_3$ is also controlled – ACI mercury capture is enhanced

- **Particulate Matter**
  - $\text{PM}_{2.5}$ is reduced – primarily by $\text{SO}_3$ capture
  - Care must be taken to not over control acid gases and negatively impact fly ash resistivity for ESP capture

- **Hydrated lime effective for some volatile metals (e.g. Se)**

- **Operational Considerations**
  - By controlling acid gas system downstream corrosion impacts are lessened
  - If injected prior to SCR ABS formation can be reduced
  - Capturing HCl prior to wet FGD keeps chlorides out of wastewater stream
  - Reaction product relatively insoluble
Summary

➢ There is a long history of using dry injection of calcium hydroxide for acid gas control

➢ Ca(OH)₂ is highly reactive with HCl

➢ Properties of Ca(OH)₂ can be controlled to maximize capture efficiency

➢ There are many factors that must be considered to determine control DSI effectiveness for any given system

➢ Combination of Ca(OH)₂ DSI with baghouse particulate collection likely to achieve HCl compliance for most industrial applications

➢ Pilot program to better define impact of injection temperature, competing acid gases and particulate control underway