SO$_2$ Control Using Dry Sorbent Injection Technology with Hydrated Lime

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Agenda

- Why Dry Sorbent Injection (DSI)?
- Hydrated Lime Sorbents
- DSI Case Studies
- Conclusions
- Summary
Why Dry Sorbent Injection (DSI)?
Why Dry Sorbent Injection (DSI)?

- Equipment is low installed capital cost
- System relatively easy to retrofit to most plants
- Small equipment footprint
- Mechanically simple system
- ~1 year schedule
  ✓ award to installation
- Low consumable requirement
  ✓ air, power
Hydrated Lime Sorbents
# Range of Products

<table>
<thead>
<tr>
<th>Sorbent</th>
<th>Standard Hydrated Lime</th>
<th>Sorbacal® H</th>
<th>Sorbacal® SP</th>
<th>Sorbacal® SPS</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure</td>
<td></td>
<td><img src="image" alt="3D Block" /></td>
<td><img src="image" alt="3D Cubes" /></td>
<td><img src="image" alt="3D Cubes" /></td>
<td>–</td>
</tr>
<tr>
<td>Typical Available Ca(OH)₂</td>
<td>92 – 95</td>
<td>93</td>
<td>93</td>
<td>93</td>
<td>%</td>
</tr>
<tr>
<td>Typical Surface Area</td>
<td>14 – 18</td>
<td>&gt; 20</td>
<td>~40</td>
<td>~40</td>
<td>m²/g</td>
</tr>
<tr>
<td>Typical Pore Volume</td>
<td>~0.07</td>
<td>0.08</td>
<td>~0.20</td>
<td>~0.20</td>
<td>cm³/g</td>
</tr>
</tbody>
</table>
DSI Case Studies
DSI Case Studies #1a and #1b

- Application ➔ Industrial Manufacturing Process
- Goal ➔ 95+% SO₂ Removal Efficiency
- Why ➔ Meet Future SO₂ Permit Limit
- Process ➔ SDA ➔ Multi-Clone ➔ DSI ➔ FF
- Flue gas temperature at DSI location 300-350°F
- DSI ➔ One (1) Injection Lance @ Fabric Filter Inlet
- Sorbent ➔ Sorbacal® SPS

<table>
<thead>
<tr>
<th>Case</th>
<th>Flue Gas Volume</th>
<th>Moisture Content</th>
<th>Baseline SO₂ Conc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>10,000</td>
<td>~14 Vol. %</td>
<td>100 ppmv</td>
</tr>
<tr>
<td>1b</td>
<td>55,000</td>
<td>~36 Vol. %</td>
<td>300 ppmv</td>
</tr>
</tbody>
</table>
DSI Case Studies #1a and #1b

95% SO₂ Removal at Mass Ratio of ~16 lb sorbent / lb Inlet SO₂

95% SO₂ Removal at Mass Ratio of ~4 lb sorbent / lb Inlet SO₂
DSI Case Study #2

- Application → 500 MW Electric Generating Utility (EGU)
- Goal → Increase Overall SO$_2$ Reduction to ~70% (40-45% Incremental SO$_2$ Removal with DSI)
- Why → Meet Future SO$_2$ Limit
- Low Sulfur Coal → Boiler → Air Heater → DSI → SDA → FF
- Process Conditions
  - Flue gas moisture ~20% relative humidity at stack
  - Baseline concentration ~225-250 ppmv SO$_2$
  - Flue gas temperature at DSI location 275-300°F
- DSI → Five (5) Injection Ports @ DSI Location
- Sorbent → Sorbacal® SPS
DSI Case Study #2

40-45% Overall SO$_2$ Removal at Mass Ratio of ~1.25 – 1.50 lb sorbent / lb Inlet SO$_2$ to achieve 70% SO$_2$ Removal Overall
DSI Case Study #3

- Application → 985,000 ACFM Cement Plant
- Goal → At Least 50% SO₂ Removal Efficiency
- Why → Comply with Future Permit SO₂ Limit
- Raw Feed & Fuel → Kiln → Pre-Heater → ID Fans → Raw Mill → Fabric Filter

- Process Conditions
  - Flue gas moisture unknown
  - Baseline concentration 15 ppmv SO₂ with Raw Mill on / 35 ppmv SO₂ with Raw Mill off
  - Flue gas temperature at DSI location
    - ID Fan Inlet 575-675°F / Fabric Filter Inlet 370-470°F
- DSI → Four (4) Injection Lances per Duct @ DSI Location
- Sorbent → Sorbacal® SPS
DSI Case Study #3

50% SO$_2$ Removal at Mass Ratio of ~11.3 lb sorbent / lb Inlet SO$_2$

50% SO$_2$ Removal at Mass Ratio of ~12.9 lb sorbent / lb Inlet SO$_2$
50% SO₂ Removal at Mass Ratio of ~11.3 lb sorbent / lb Inlet SO₂

50% SO₂ Removal at Mass Ratio of ~16.7 lb sorbent / lb Inlet SO₂
DSI Case Study #4

• Application → 580 SCFM Pilot Plant
• Goal → Compare Relative SO₂ Removal Efficiency
• PRB Coal → Boiler → DSI → Heat Exchanger → ESP

• Process Conditions
  ✓ Flue gas moisture ~9% by Volume
  ✓ Baseline concentration ~150 ppmv SO₂
  ✓ Flue gas temperature at DSI location ~700-750°F

• DSI → One (1) Injection Lance @ DSI Location
• Sorbents → Standard Hydrated Lime & Sorbacal® SPS
50% SO₂ Removal at Mass Ratio of ~2.7 lb sorbent / lb Inlet SO₂

50% SO₂ Removal at Mass Ratio of ~4.5 lb sorbent / lb Inlet SO₂
Conclusions / Discussion
Conclusions

• All cases were successful in achieving target $\text{SO}_2$ removal efficiency using DSI technology with hydrated lime sorbent

• Cases 1a and 1b
  ✓ DSI using Sorbacal® SPS able to achieve high $\text{SO}_2$ removal efficiencies (> 95%)
  ✓ Flue gas moisture content appears to be primary factor driving better performance in Case 1b

• Case 2
  ✓ DSI using Sorbacal® SPS effective solution for $\text{SO}_2$ trim application even on large scale
Conclusions

• Case 3

✓ DSI using Sorbacal® SPS able to achieve target SO$_2$ removal at various injection locations under varying conditions

✓ Demonstrated high SO$_2$ removal (85-90%) at three (3) injection locations

✓ Illustrates why each site must be evaluated on case by case basis

• Case 4

✓ DSI using Sorbacal® SPS was ~40% more efficient than standard hydrated lime for SO$_2$ control at 700-750°F injection temperature based on PRB coal
Summary
Summary

- DSI technology using hydrated lime sorbents viable SO$_2$ compliance solution
- Flue gas moisture important for performance
- Sorbent properties also important
  - standard hydrated lime vs. enhanced hydrated limes
- Path Forward:
  - Additional SO$_2$ trials to understand how different parameters impact performance
  - Improve flue gas to sorbent mixing
  - Improve understanding of impacts of competitive reactions, flue gas temperature, flue gas moisture, sorbents, etc. on SO$_2$ removal
  - High temperature applications (furnace injection)
Thank you!!

If you have any questions feel free to contact,

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