Worldwide Pollution Control Association

Dry Scrubbing
O&M Training

APC/PCUG Conference
July 12-16, 2009
The Woodlands, TX

Visit our website at www.w pca.info
Spray Dryer Absorber O&M Considerations

WPCA Dry Scrubbing O&M Seminar
The Woodlands, Houston, TX
July 12, 2009
SDA Operations & Maintenance

- Key SDA Operating Considerations
- Boiler Load Following and Ramping
- SDA Byproduct Properties
  - Fly Ash Pre-Collection Impacts
- SDA Byproduct Handling Systems
- Process Upsets
- Troubleshooting Tools and Experience
**Typical SDA Control Concepts**

Instrument verification is critical for optimal performance.

- **SO₂ Emission Setpoint**
- **SO₂ Monitor**
- **Recycle Slurry Solids Setpoint**
- **Density Monitor**
- **Recycle Solids**
- **H₂O**
- **Lime**
- **H₂O**
- **Slaker Temperature Setpoint**
- **TCs**
- **Absorber Outlet Temperature Setpoint**
- **Flow Feed Forward**

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WPCA DFGD O&M 07_12_09
Important Control Considerations

• SDA outlet temperature response time
• Safe operating temperature is function of slurry solids loading
• Maintain margin above saturation
• “Chemistry” generally not used for process control
  • Byproduct moisture
  • Cl in byproduct
  • Conductivity of recycle slurry
What Determines SDA Consumables?

**Lime Use**

Inlet conditions, lime and water quality and required performance

**Pressure Drop**

Flue gas flow and conditions, arrangement, SDA selection, FF design and operation

**Power Consumption**

Gas flow and temperature, slurry solids loading and flow

**Water Use**

Gas flow and temperature, spraydown
Typical Lime Specification

- **High calcium quicklime (CaO)**
- **Particle Size**
  
  ¾ inch x 0 with no more than 50% less than 10 mesh
- **Availability**
  
  90% CaO or greater per ASTM C25
- **Reactivity**
  
  40°C temperature rise or greater in 3 minutes
  Total temperature rise in 10 minutes max
  ASTM C110
- **Chemical Analysis**

  - CaO: 90 – 98 wt.%
  - MgO: 0.5 – 1.5 wt.%
  - Inerts: 10% max
  - LOI: 1.5% max
Pebble Lime Handling Considerations

• Design for minimizing particle break-up in transport
  • Minimize transport distance
  • Long sweep elbows
  • Silo target box design
• Size slaker feed for expected particle size distribution at feeder rather than delivered lime specification
• Provide for slaking water heating to optimize slaker performance
Load Ramping

- **Increasing load** – increase lime slurry flow in manual control ahead of load
- **Automatic control - feed forward**
  - Stack gas flow or MW output - too late
  - Flue gas temperature - too variable
  - “Compensated” coal flow recommended
- **Avoid “valves wide open” operation**
- **Rapid load drop**
  - May see solids drop out in SDA w/o a solids handling system under SDA
- **Emissions averaging period considerations**
SDA Byproduct Considerations

• No “byproduct quality control” step in the SDA FGD process as incorporated in WFGD gypsum production

• Trace elements from coal, flue gas, lime and process water streams end up in byproduct

• Byproduct quantity and composition does not vary widely over normal anticipated range of SDA operating conditions
Byproduct Generation Rule-of-Thumb

Ratio of lb byproduct solids / lb SO₂ removed

2.5 to 3.0

• Excluding fly ash
• 2.5 is good first estimate for Western coals
• 0.2 to 1.0 % S in coal
• 90 to 94% SO₂ reduction
### SDA Operation Impact on Byproduct Solids

**Increase SO₂ removal by increasing lime use**

<table>
<thead>
<tr>
<th>% Removal</th>
<th>Byproduct Solids</th>
<th>% Ca(OH)₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>-2.5%</td>
<td>0.09</td>
</tr>
<tr>
<td>85</td>
<td>-1.3%</td>
<td>0.16</td>
</tr>
<tr>
<td>90</td>
<td>Base</td>
<td>0.27</td>
</tr>
<tr>
<td>95</td>
<td>+1.5%</td>
<td>0.50</td>
</tr>
</tbody>
</table>

**Reduce lime use by lowering temperature**

<table>
<thead>
<tr>
<th>Approach Temperature</th>
<th>Byproduct Solids</th>
<th>% Ca(OH)₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>-0.3%</td>
<td>0.14</td>
</tr>
<tr>
<td>30</td>
<td>-0.2%</td>
<td>0.20</td>
</tr>
<tr>
<td>35</td>
<td>Base</td>
<td>0.27</td>
</tr>
<tr>
<td>40</td>
<td>+0.2%</td>
<td>0.37</td>
</tr>
<tr>
<td>45</td>
<td>+0.4%</td>
<td>0.47</td>
</tr>
<tr>
<td>50</td>
<td>+0.6%</td>
<td>0.60</td>
</tr>
</tbody>
</table>

**35°F Approach Temperature**

**90% SO₂ Removal**
Fly Ash Pre-Collection

ESP

SDA

BH / ESP

Lime

Recycle Solids

H$_2$O

H$_2$O

Fly ash Pre-Collection
Solids Mass Balance w/o Pre-Collection

11.56 gr/acf

1.29 gr/acf

Fly ash
16,537 lb/hr

SDA

 BH / ESP

Disposal / Utilization
20,651 lb/hr

Recycle Solids
107,025 lb/hr

CaO
1,681 lb/hr

92% SO₂ Removal

By-product / Recycle Solids Composition (wt. %)

<table>
<thead>
<tr>
<th>Fly Ash</th>
<th>79.75</th>
<th>Inerts</th>
<th>0.62</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Water</td>
<td>1.00</td>
<td>Crystal Water</td>
<td>1.77</td>
</tr>
<tr>
<td>CaSO₃</td>
<td>13.25</td>
<td>CaSO₄</td>
<td>2.73</td>
</tr>
<tr>
<td>CaF₂</td>
<td>0.00</td>
<td>Ca(OH)₂</td>
<td>0.34</td>
</tr>
<tr>
<td>CaCl₂</td>
<td>0.16</td>
<td>CaCO₃</td>
<td>0.38</td>
</tr>
</tbody>
</table>
**Solids Mass Balance with Pre-Collection**

- **Fly ash**: 165 lb/hr
- **Disposal / Utilization**: 4,313 lb/hr
- **92% SO₂ Removal**

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**By-product / Recycle Solids Composition (wt. %)**

<table>
<thead>
<tr>
<th></th>
<th>Fly Ash</th>
<th>Free Water</th>
<th>CaSO₃</th>
<th>CaF₂</th>
<th>CaCl₂</th>
<th>Inerts</th>
<th>Crystal Water</th>
<th>CaSO₄</th>
<th>Ca(OH)₂</th>
<th>CaCO₃</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>%</strong></td>
<td>4.28</td>
<td>1.00</td>
<td>62.70</td>
<td>0.00</td>
<td>0.76</td>
<td>4.55</td>
<td>8.37</td>
<td>12.91</td>
<td>3.91</td>
<td>1.53</td>
</tr>
</tbody>
</table>
SDA Byproduct Solids

**Without Ash Pre-collection**

**With Ash Pre-collection**
### SDA Byproduct - Key Material Properties

<table>
<thead>
<tr>
<th></th>
<th>No pre-collection</th>
<th>Fly ash pre-collection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Average</td>
</tr>
<tr>
<td><strong>Particle Size, D90 μm</strong></td>
<td>34 – 71</td>
<td>47</td>
</tr>
<tr>
<td><strong>Particle Size, D50 μm</strong></td>
<td>3 – 16</td>
<td>6</td>
</tr>
<tr>
<td><strong>Particle Density, bulk density lb/ft³</strong></td>
<td>37 – 42</td>
<td>39</td>
</tr>
<tr>
<td><strong>Particle Density, tap density lb/ft³</strong></td>
<td>61 - 71</td>
<td>64</td>
</tr>
</tbody>
</table>

Comparison based on limited fly ash pre-collection sample data
Fly Ash Pre-Collection Impacts

• Need byproduct handling system flexibility
  • Capacity with pre-collector out of service
  • Range of material properties expected
• Changes nature of the solids
  • Composition – relatively higher Ca(OH)$_2$ and CaCl$_2$
  • Shape – irregular shapes result in higher void fraction and more interlocking
  • More tendency to cake, but fluidizes easily on aeration
Byproduct Handling – Vacuum System
Byproduct Handling – Pressure System
Byproduct Handling – Vacuum/Pressure System
## Byproduct Handling System Comparison

<table>
<thead>
<tr>
<th>System Feature</th>
<th>Vacuum</th>
<th>Vacuum/Pressure</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower hopper area headroom Required</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Long ash material transport distance</td>
<td></td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Lower initial cost</td>
<td>✔️</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less hopper area housekeeping</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Higher ash loading capacity</td>
<td></td>
<td></td>
<td>✔️</td>
</tr>
<tr>
<td>Simplified silo/collection Equipment</td>
<td></td>
<td></td>
<td>✔️</td>
</tr>
<tr>
<td>Fewer moving parts, less life cycle maintenance</td>
<td>✔️</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Byproduct Handling System Considerations

- Conveying velocity 10 to 20% higher than fly ash system
- Good experience with straight drop through valves
- Pre-heat conveying lines – maintain warm lines when not transporting solids
- Rubber elbows in transport lines can help prevent build-up
- Consider insulating transport lines
Byproduct Disposal

• Pug mill conditioner
  • Water added at 12 to 25% by weight with free lime a factor in determining optimal moisture
  • With fly ash pre-collection – may need to add ash back in to the mix to stabilize
• Non-stick surfaces to reduce build-up
Process Upsets You May Encounter

• Low recycle slurry solids
  • Adjust SDA operating conditions to maintain good drying
• Loss of recycle slurry feed
  • Design for lime only operation
• Low SDA inlet temperature
  • May limit ability to add sufficient reagent
Troubleshooting Tools and Experiences

- Tools to verify operating conditions
- Use of thermal imaging
- Temperature distribution mapping
Slurry Solids Moisture Balance
Moisture Balance Uses

**Dry & Weigh Scale**
- Confirm lime slurry solids (105°C, < 1mg/60sec)
- Confirm recycle slurry solids (85°C, < 1mg/60sec)
- Measure slurry and water TDS
- Measure recycle ash moisture content

**Weigh Scale**
- Check slurry density measurement.
- Confirm solids specific gravity constants programmed into density monitor
Wet Bulb Temperature Measurement
Wet Bulb Temperature Variability

Stack Twb Vaisala/Wick = 127F/129F @ 1700

HydroBlasters

IK's 13/16, 22/26

IK's 11, 17, 18, 19
Infrared Thermography
SDA Spray Chamber
Baghouse Following SDA
Baghouse Ash Valve Heat Tape
Baghouse Ash Valve and Transport Line

\[ P_0 = 69^\circ F \]
\[ A_1 = 79^\circ F \]
\[ A_2 = 112^\circ F \]
Confirm SDA Vessel Drying Profile

Tin - Tout - Tas
269F - 163F - 38F

Tmax - Tavg - Tmin - Feed Solids
168F - 165F - 160F - 40.3%

MAXTref
-2F

Port 1
Port 2
Port 3
Port 4
Port 5
Port 6
Port 7
Things That Can Sneak Up On You

• Change in water quality
  • Strainer, cooler and cooling water line pluggage
  • Screen blinding
• Fuel change
  • May need to modify operations if significant change in Cl
• Difficulty in maintaining slurry solids
  • Leaking flush valves
  • Excessive screen wash or loss of nozzle
• Excessive flushing
  • Longer and higher pressure flushing is not necessarily a good thing
• Instrument calibration
Key Spare Parts to Consider

- Atomizer assembly
- Miscellaneous key atomizer components
  - Rotary - gear set, spindle, bearings, wheel, nozzles
  - Dual Fluid – end cap, mix chambers, nozzles
- Slurry tanks
  - Agitator gear box
  - Agitator shaft
- Slurry feed
  - Critical hoses and connections
SDA O&M Summary Comments

- O&M costs – EIA Data – about $1.00/MWhr(net)
- Atomizer PM
  - Rotary - 1 to 3 month cycle typical
  - DFN – weekly inspect and clean
- Practice good atomizer parts tracking to optimize spare parts inventory and avoid unplanned maintenance
- Experiences and practice with slurry train swapping varies widely
- Take advantage of each outage to inspect internals and piping
- Establish a long-term corrosion monitoring plan
Thank You!

Kevin Redinger
B&W