WPCA Scrubber Seminar

WFGD Maintenance

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Babcock Power Environmental Inc.
Total Cost

Capital Cost

Operating & Maintenance Cost
Wet Scrubbing Challenges

- Liquid to Gas Ratio
- Oxidation
- Chloride Concentration (Blowdown)
- Gypsum
- O&M
- Turndown
FGD Maintenance Challenges

• Mist Eliminator Washing
• Plugged Nozzles/Lines
• Filtering Process
• Limestone/lime Storage-prep
• Cleaning/Safety
• Availability
  – Outage schedule
• Compliance
New nozzles tend not to plug

Old nozzle design – plugging problems
Absorber Internals
Absorber Island
Cutaway View Showing Absorber Internals

Primary & Secondary Mist Eliminators

Recycle Piping (Discharge)

Agitators 6+1 configuration

4 + 1 Recycle Pumps

4+1 Recycle Spray Headers & Nozzles

Maintenance Floor w/Support Beams (Optional Scope)

Isolation Valves

Suction & Discharge reducers 15° Slope minimizes wear

Recycle Piping (Suction)
Note: All Elevations Spray In 2 Directions Except the Top Spray Level To Avoid Clogging of Mist Eliminators

Isometric View Showing Spray Pattern Across Five Levels
• Spray Nozzles Arranged
  To Provide Full Coverage Across
  The Section of the Absorber
• Outer Nozzles Arranged to Ensure
  Maximum Coverage
  And Reduce Impingement at
  The Absorber Wall
90° Spray Pattern (Outer Nozzles)

120° Spray Pattern (Inner Nozzles)

Absorber Wall

Wall Ring

Main Recycle Spray Header Piping
• Wall Ring @ Spray Levels 2 & 4 Ensure No Gases Flow Thru At Wall Unrestricted
• Spray Nozzles and Piping Arranged to Minimize Vertical Alignment of Nozzles and Maximize Spray Pattern Coverage
Maintenance Support Grid

App. 7’ x 10’ Channel Iron Grid
Located Below Bottom Spray Level

Absorber Wall
Scaffolding Provides Convenient And Safe Access to Nozzles
Allows Maintenance at the Upper Levels To Be Performed at the Same Time as Maintenance In the Reaction Tank Area (No Fall Thru).
FGD Absorber Internals
Weather Protected Limestone Storage and Feeding
Enclosed Ball Mill for Sound Protection and Maintenance in Cold Climate

Outdoor Ball Mill
Warm Climate
Maintenance Crane
Oxidation Air Blowers in Sound Enclosure
Dewatering System

HYDROCYCLONE
UNDERFLOW

AIR

WASH WATER

SLURRY - CAKE

BELT FILTER

VACUUM PUMP

FILTRATE RECEIVER

FILTRATE PUMP
Gypsum Dewatering

Hydrocyclone & Belt Filter Arrangement
Power Optimization

Design Influence

• Recycle Pumps
• Fans – Gas Side DP
• Oxidation Air Blowers
• Limestone Grinding Mills

Operational Influence

• On-line Optimization
• Automatic and in Real Time
Power Optimization
Oxidation & Agitation

• Tank Sizing
  – Limestone Dissolution
  – Oxidation
    • Mixing
    • Residence Time
  – Reaction Completion
    • De-supersaturation
  – Gypsum Crystal Growth
    • Size
    • Shape
• On-line Monitoring
Power vs. SO₂ Removal
750 MW East. Bituminous Coal

Wet FGD Power Usage

<table>
<thead>
<tr>
<th>SO₂ Removal</th>
<th>95%</th>
<th>97%</th>
<th>99%</th>
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<tbody>
<tr>
<td>Booster Fan kW</td>
<td>4,253</td>
<td>4,593</td>
<td>5,303</td>
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<tr>
<td>Recycle Pumps kW</td>
<td>4,160</td>
<td>4,593</td>
<td>6,961</td>
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<tr>
<td>Oxidation Air Blowers kW</td>
<td>2,315</td>
<td>2,556</td>
<td>3,500</td>
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<tr>
<td>Ball Mills kW</td>
<td>1,614</td>
<td>1,648</td>
<td>1,682</td>
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<tr>
<td>Others kW</td>
<td>2,660</td>
<td>2,710</td>
<td>2,772</td>
</tr>
<tr>
<td>total kW</td>
<td>14,572</td>
<td>16,100</td>
<td>20,218</td>
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Operation and Maintenance
Operational History - Inspection

Hardened sludge in fiberglass header - cut out for access.
Operational History - Inspection
Layout Impacts Number of Operating Personnel

- Gypsum loading barge
- Gypsum storage silos
- Limestone unloading & Storage
- Ball mills and recycle pumps
O & M Criteria

- **Safety**
  - Balance between initial capital cost vs. long-term operating cost
  - Plant availability/redundancy
  - Operating economics
    - Elevators vs. stairs
    - Weather encloses
- **Wash down/Cleaning**
  - Drains/pits/pumps
- **All in one building**
Limestone preparation, recycle pumps, control room and gypsum system in one building for reduced operating cost

Elevator
Isolation Valves for Pump Maintenance
All pumps in straight line/overhead cranes

Note wide maintenance aisles

Floor drains
Overhead crane for maintenance

Room between pumps for forklift
Overhead cranes
Recycle pump screens to prevent pump wear and nozzle plugging
## Operational WFGD Testing Requirements

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Test Method</th>
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<tbody>
<tr>
<td>pH</td>
<td>EPRI – C1</td>
</tr>
<tr>
<td>Density</td>
<td>EPRI – D2</td>
</tr>
<tr>
<td>Wt % of Solids</td>
<td>EPRI – F3</td>
</tr>
<tr>
<td>Chemical Composition – Sulfate</td>
<td>EPRI – L2</td>
</tr>
<tr>
<td>Chemical Composition – Sulfite</td>
<td>EPRI – M1</td>
</tr>
<tr>
<td>Chemical Composition – Carbonate</td>
<td>EPRI – N3</td>
</tr>
<tr>
<td>Particle Size</td>
<td>EPRI – G1</td>
</tr>
<tr>
<td>Crystal Water</td>
<td>ASTM C471M</td>
</tr>
<tr>
<td>Residual Moisture</td>
<td>ASTM C471M</td>
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<tr>
<td>Chloride</td>
<td>EPRI– I3</td>
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## Operational WFGD Testing Requirements

<table>
<thead>
<tr>
<th>Frequency of Sampling</th>
<th>pH</th>
<th>Density</th>
<th>Wt% of Solids</th>
<th>Chemical Composition of Solids SO$_4$ SO$_3$ CO$_3$</th>
<th>Particle Size Distribution</th>
<th>Cl- Content</th>
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</thead>
<tbody>
<tr>
<td>Slurry Recycle</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X (2/week)</td>
<td>X</td>
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<tr>
<td>Gypsum Slurry</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>--</td>
</tr>
<tr>
<td>Gypsum</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Limestone Slurry</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Limestone</td>
<td>Weekly composite</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Ball Mill Hydrocyclones</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>Make Up Water</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Waste Water</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Operational WGFD Testing Manpower

- Man-hours per absorber 14.5 hours / week
- Man-hours plant common systems
  - Reagent system 15.5 hours / week
  - Water system 4.5 hours / week
  - Gypsum byproduct 4 hours / week
- Man-hour estimate 2 absorbers and common systems 53 hours
- Man-hour estimate 2 absorbers and common systems 2756 hours
Periodic Mechanical Inspection

- Pumps – Check
  - Oil level
  - Seal leakage
  - High vibration
  - Belt tension
  - Bearing temperature
  - Alignment

- Agitators – Check
  - Oil level
  - High vibration
  - Gland seal water leakage

- Strainers
  - Differential pressure each shift, clean if high
Periodic Electrical Inspection

- **Motors – Check**
  - Bearing temperature
  - Insulation resistance
  - Bearing vibration
  - Brush wear
  - Slip ring roughness
  - Motor heater current
  - Clean parts of carbon dust

- **Electrical**
  - Annual inspection or per manufactures instructions

- **Relays**
  - Differential pressure each shift, clean if high

- **Instrumentation**
  - Per manufactures instructions
Periodic Maintenance Manpower

- Man-hours per absorber 20 hours / week
- Man-hours plant common systems
  - Reagent system 20 hours / week
  - Assist with Operational Testing 20 hours / week
- Man-hour estimate 2 absorbers and common systems 80 hours
- Man-hour estimate 2 absorbers and common systems 4160 hours
Operation and Maintenance Manpower

- **WFGD Operator**, current control room operator from each unit will monitor and control
- **Assistant WFGD Operator**, one required for plant, perform WFGD operational testing
- **Maintenance Mechanic**, two required for plant, perform periodic maintenance and assist with testing
Scheduled Outage Inspection

• Absorber Tank
  – Inspect for corrosion, scale and deposits
  – Remove loose material
  – Map location of deposits
  – Repair lining as needed
• Spray Headers and Nozzles
  – Check spray nozzles for plugging and map
  – Clean or replace nozzles as necessary
  – Check headers for erosion
• Mist Eliminators
  – Check for damage or deposits
  – Check wash system for valve function and coverage
• Reagent Preparation
  – Inspect and repair in accordance with manufactures’ instructions
Outage and Maintenance Costs

• Estimated outage (3 yr) cost $250,000 / absorber including
  – Absorber scaffolding
  – Sump cleaning
  – Absorber vessel and header repairs

• Estimated yearly maintenance cost $150,000 / absorber including
  – Agitator parts
  – Recycle pump rebuilds
  – Misc. pump rebuilds
Owners Decisions

- Redundancy
  - Pumps
  - Ball Mills – 3 x 50% or 2 x 100%
  - Dewatering
  - Spares
- Organic Acids
- Waste Water
- Gypsum Markets/landfilling
Absorber Access

• **Safety First**
  - Confined Space
  - Fall Protection
  - Personal Safety Equipment
  - Working Conditions: Lighting, GFI's, Tools, Noise, Welding. Flash Protection, etc.

• **Maintenance**
  - Minimize outage time
  - Simple PM programs
  - Easy access for service and cleaning
Ghent Station Unit 3 Absorber Island Plan View

- **2 - Gypsum Transfer Tanks ea.207,000 gal.**
  - Carbon Steel (Rubber Lined)
  - Return from 3 Recycle Pumps
  - Each With Agitators

- **1 - Process Water Tank 85,500 gal.**
  - Carbon Steel
  - 2 Redundant Mist Eliminator Wash Pumps

**Oxidation Air Compressors**

**Recycle Pumps**

**2nd Stage Mist Eliminator Access Platform**
- Wrap Around Design Provides Access To Spray Header Valves
- A Lay Down Area for Demister Modules

**Existing Unit 1 FGD Stack**
Ghent Station Unit 3 Absorber Island
Cutaway View Showing Absorber Internals

Primary & Secondary Mist Eliminators
Recycle Piping (Discharge)
Agitators 6+1 configuration
4 + 1 Recycle Pumps

4+1 Recycle Spray Headers & Nozzles
Maintenance Floor w/Support Beams (Optional Scope)
Isolation Valves
Suction & Discharge reducers 15° Slope minimizes wear
Recycle Piping (Suction)
## Equipment Delivery

### In Weeks

<table>
<thead>
<tr>
<th>Commodity</th>
<th>2003</th>
<th>2008</th>
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<tbody>
<tr>
<td>Structural Shapes</td>
<td>8-12</td>
<td>20-24</td>
</tr>
<tr>
<td>Recycle Pumps</td>
<td>26-30</td>
<td>56</td>
</tr>
<tr>
<td>Ball Mills</td>
<td>26-30</td>
<td>75</td>
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<tr>
<td>ID Fans</td>
<td>72</td>
<td>64</td>
</tr>
<tr>
<td>SCR Catalyst</td>
<td>46-48</td>
<td>52-54</td>
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Typical Maintenance Issues

• Mist Eliminator Plugging
• Scaling and Buildup of Solids
• Low SO₂ Removal
• Gypsum Quality
• Reagent Usage

Many Common Issues or Conditions Impact Maintenance and Operations
Mist Eliminator Plugging

- Water quality
- Broken/missing/plugged nozzles
- High gas velocity
Scaling and Buildup of Solids

- Wet Dry interface
- Chemistry
- Oxidation air system
- Limestone quality or sizing
Low SO$_2$ Removal

- Sorbent preparation/sizing/quality
  - Feed rate
- Blinding
  - Sulfite or aluminum fluoride
- Plugged nozzles
- pH monitor
Gypsum Quality

- Reagent preparation & utilization
  - Sizing/quality
- Oxidation air
- Belt filter and hydrocyclones
- Wash water
Reagent Usage

- pH monitor
- Sorbent quality and grind size
- Blinding
  - Sulfite or aluminum fluoride
Thank You

Questions ??