WPCA Scrubber Seminar

FGD Design and Operating Criteria

Tony Licata

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

Maintenance Floor w/Support Beams (Optional Scope)
Isolation Valves
Suction & Discharge reducers 15° Slope minimizes wear
Recycle Piping (Suction)
Isometric View Showing Spray Pattern Across Five Levels

Note: All Elevations Spray In 2 Directions Except the Top Spray Level To Avoid Clogging of Mist Eliminators
• 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
Wall Ring
Absorber Wall

90° Spray Pattern (Outside Nozzles)

120° Spray Pattern (Inside Nozzles)

Main Recycle Spray Header Piping

Typical Ø 5” Nozzles

Typical Spray Header Branch Line
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
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. SO\textsubscript{2} Removal

750 MW East. Bituminous Coal

#### Wet FGD Power Usage

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

Gypsum loading barge

Gypsum storage silos

Ball mills and recycle pumps

Limestone unloading & Storage
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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<tr>
<td>pH</td>
<td>EPRI – C1</td>
</tr>
<tr>
<td>Density</td>
<td>EPRI – D2</td>
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<tr>
<td>Wt % of Solids</td>
<td>EPRI – F3</td>
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<tr>
<td>Chemical Composition – Sulfate</td>
<td>EPRI – L2</td>
</tr>
<tr>
<td>Chemical Composition – Sulfite</td>
<td>EPRI – M1</td>
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<tr>
<td>Chemical Composition – Carbonate</td>
<td>EPRI – N3</td>
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<tr>
<td>Particle Size</td>
<td>EPRI – G1</td>
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<tr>
<td>Crystal Water</td>
<td>ASTM C471M</td>
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<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></th>
<th>Frequency of Sampling</th>
<th>pH</th>
<th>Density</th>
<th>Wt% of Solids</th>
<th>Chemical Composition of Solids SO₄ SO₃ CO₃ Inert</th>
<th>Particle Size Distribution</th>
<th>Cl- Content</th>
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<tr>
<td>Slurry Recycle</td>
<td>1x per day</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>1x per week</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Gypsum</td>
<td>1x per week</td>
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<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Limestone Slurry</td>
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<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></td>
<td></td>
<td></td>
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<td>Ball Mill Hydrocyclones</td>
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<td></td>
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<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Make Up Water</td>
<td>1x per week</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Waste Water</td>
<td>1x per week</td>
<td>x</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
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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, GFIs, 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
- Maintenance Floor w/Support Beams (Optional Scope)
- 4+1 Recycle Spray Headers & Nozzles
- 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>
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<tr>
<td>Recycle Pumps</td>
<td>26-30</td>
<td>56</td>
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<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>
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<tr>
<td>SCR Catalyst</td>
<td>46-48</td>
<td>52-54</td>
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What are can be done to shorten time line?

- Qualifying new vendors
- Packaging components
- New construction techniques
- Standard designs
- New design tools
Thank You

Questions ??