Improved Fuel Flexibility by Addressing the Fundamentals of Combustion

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Prepared and Presented By:
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• Overview of Allen Steam Station
• Driving Factors of Fuel Switch
• Comparison of Coals
• Initial ILB Burn Results
• Action Plan Implemented by Duke and Storm Personnel
• Test Burn Findings & Results
• Conclusions
Overview of Allen Steam Station

- Boiler Design
  - 1950’s CE Subcritical, Tangential Fire Boilers – (Twin Furnace Design)
  - Superheat and Reheat Furnace
  - Common Steam Drum

- Pulverizer Design
  - (8) 633 Raymond Deep Bowl Mills – 4 per Boiler

- Pressure Part Design/History
  - Platen vs. Pendant Tube Spacing

- Burner Design
  - First Generation Wide Range Burners

- Emission Control Systems
  - SNCR
  - ESP
  - ACI
  - WFGD

- Design Fuel
  - Eastern Bituminous
Factors Behind Fuel Switch

- A Need to Stay Competitive and An Economically Viable Source of Electricity
  - Abundance of Low Cost Natural Gas
  - Highly Efficient Combined Cycle Units
  - Numerous Supercritical Boilers in the Fleet

![Graph](image_url)

*Source: U.S. Energy Information Administration, based on Natural Gas Intelligence*
Comparison of Coals

- Allen Steam Station has historically fired boiler friendly CAPP – Central Appalachian coals
- Lower cost ILB – Illinois Basin coals that were purchased were extremely boiler unfriendly
  - Sulfur content increased 262%
  - Iron content increased 345%
  - Chlorine content is 0.16% - 0.19% on average
  - Reducing ash fusion temperatures are 500°F - 600°F lower
  - Free Swell Index (FSI) increased 6 pts
  - HGI increased 10 pts
  - HHV increased 1,000 Btu/lb

<table>
<thead>
<tr>
<th>Description</th>
<th>Units</th>
<th>CAPP</th>
<th>ILB</th>
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<tbody>
<tr>
<td>Higher Heating Value</td>
<td>Btu/lb</td>
<td>11,525</td>
<td>12,287</td>
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<tr>
<td>Moisture</td>
<td>%</td>
<td>7.38</td>
<td>7.28</td>
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<tr>
<td>Ash</td>
<td>%</td>
<td>18.00</td>
<td>10.17</td>
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<tr>
<td>Sulfur</td>
<td>%</td>
<td>0.97</td>
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<tr>
<td>Volatile Matter</td>
<td>%</td>
<td>30.5</td>
<td>35.82</td>
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<tr>
<td>Ash Loading</td>
<td>lbm/MMBtu</td>
<td>13.96</td>
<td>8.28</td>
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<tr>
<td>SO₂</td>
<td>lbm/MMBtu</td>
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<td>5.71</td>
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<td>B/A Ratio</td>
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<td>0.16</td>
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<tr>
<td>HGI</td>
<td></td>
<td>44</td>
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<tr>
<td>FSI</td>
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<td>Softening</td>
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<td>XXXX</td>
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<tr>
<td>Hemisphere</td>
<td>°F</td>
<td>XXXX</td>
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<tr>
<td>Fluid</td>
<td>°F</td>
<td>XXXX</td>
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<td>1,964</td>
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<tr>
<td>Softening</td>
<td>°F</td>
<td>2,600</td>
<td>1,996</td>
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<tr>
<td>Hemisphere</td>
<td>°F</td>
<td>2,700+</td>
<td>2,064</td>
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<tr>
<td>Fluid</td>
<td>°F</td>
<td>2,700+</td>
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Coal Quality

- Minerals in the coal they are a dynamic factor in the slagging characteristics in the boiler
  - Base/Acid Ratio Ranged from 0.57 – 0.78
  - Iron content ranged from 25% - 30%
Initial ILB Burn Results

- 100% conversion to ILB coal under normal operating conditions due to limited coal blending opportunities/equipment design
- Severe slagging was observed in a matter of shifts
- This was seen during multiple attempts to fire ILB coals
- Firing to attain steam temperatures
  - Non-operational tilts
  - Air/Fuel dampers non-operational
  - RH sprays isolated
- Forced outages requiring explosive and hydro blasting
- Burner compartment fires
Plan of Action

• Duke and Storm worked together to develop a plan in order to burn the challenging ILB coals

• Prior to testing
  • All auxiliary air and fuel air dampers were stroked and visually verified internally
  • To ensure complete knowledge of coal quality, “real-time” samples were collected and sent off for analysis
  • Established test team:
    • Testing Coordinator
    • Site Liaison
    • Test Team Members
    • Management
  • Analyzed risk(s) associated with reliability during peak season

• Reviewed coal treat validity

• Tuned boiler on high ash CAPP coal first

• Initiated ILB tuning parameters
  • Based on CAPP data
Test Plan

• Areas to be addressed:
  • Pulverizers:
    • Dirty Air and Fuel Balance
    • Fuel Fineness
    • Air/Fuel Ratios
  • Flue Gas Measurements:
    • Furnace Exit
      • HVT Traverses to determine FEGT’s, \(O_2\), CO and \(NO_x\)
    • Economizer Outlet
      • Traversed ducts to evaluate flue gas constituents and determine air in leakage rates
  • Flyash Collection:
    • Insitu flyash samples were collected across each of the three air heater inlet ducts
  • Raw Coal Collection:
    • Raw coal samples were collected out of each hopper, each day
Initial Test Results

- Test results on CAPP coal
  - Pulverizer performance
    - Fineness levels were very low
    - 52% - 65% passing 200 mesh
    - 2% - 4% retained on 50 mesh
  - Classifier adjustments were made to address fineness prior to ILB coal
Initial Test Results

- Test results on CAPP coal
  - Flue gas measurements
    - Low in furnace excess oxygen levels with areas measuring <1%
    - Economizer exit testing revealed an average of 3% excess oxygen.
    - Approximately 5% air in leakage measured between furnace and excess oxygen probes

Excess oxygen levels greatly improved prior to introducing ILB Coal
Initial Test Results

- Test results on CAPP coal
  - Flyash Analysis
    - 3-part Flyash analysis completed
      - Average fineness level 86%
      - Following classifier adjustments fineness improved to above 90%
      - LOI’s improved throughout the testing/tuning on CAPP coal

**Storm Technologies, Inc.**
**Duke Energy - Allen: Unit 4**
CAPP Flyash LOI Results

**Storm Technologies, Inc.**
**Duke Energy - Allen: Unit 4**
Flyash Fineness Results

*Flyash % Passing 90 to 95% is the min. recommended goal to achieve for optimum pulverizer performance and is shown with the yellow highlighted area above*
ILB Test Burn Results

- Test results on ILB coal
  - Pulverizer performance
    - Classifiers were adjusted on 7 of 8 mills to improve fineness
    - Average of 74% passing 200 mesh
    - Average 1.2% retained on 50 mesh
    - Average mean particle size improved 26%
ILB Test Burn Results

- Test results on ILB coal
  - Flue gas measurements
    - Excess oxygen bias increased to provide desired average of 3% excess oxygen
    - WB/Furnace DP’s optimized to improve combustion.
    - SOFA & CCOFA’s optimized for combustion and steam temperatures

Additional Tuning
Further Improved Excess Oxygen Levels and Distribution
ILB Test Burn Results

- Test results on ILB coal
  - Flyash Analysis
    - 3-part Flyash analysis completed
      - Average fineness results within recommended range
      - LOI’s remained relatively unchanged throughout the testing
Final Conclusions and Results

• The presence of an oxidizing environment is extremely important
• Fuel fineness levels must be optimized to minimize fuel imbalances and secondary combustion
• Aux air and Fuel air damper operation is critical to balancing in furnace excess oxygen
• Sootblower operation must be optimized (i.e. pressures and travel)
• Allen was able to successfully operate with ZERO coal treat throughout the summer with no slagging incidents
• Allen has continued to burn a combination of 100% ILB coal on Units 4 and 5.
• Post summer run boiler inspections noted no significant slag buildup in problem areas identified during the initial ILB test burn
• Budget impacts/equipment damage reduced by eliminating explosive blasting
Thank You

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