Improved Fuel Flexibility by Addressing the Fundamentals of Combustion

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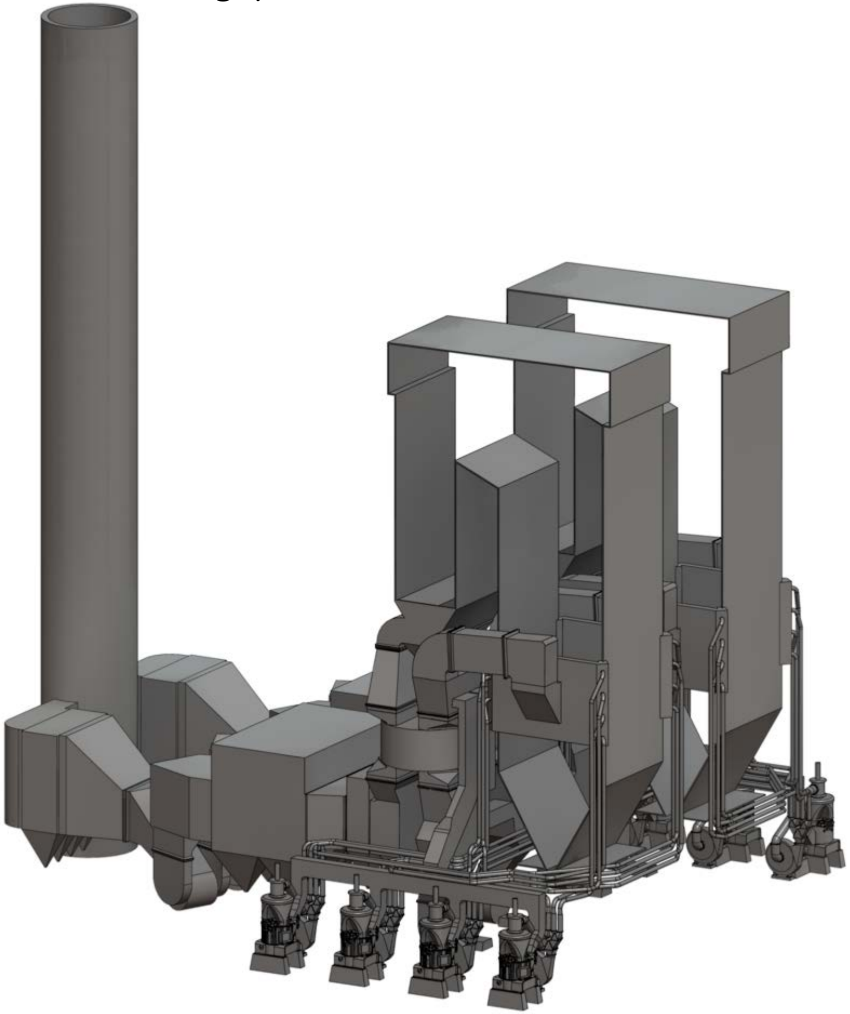
Outline

- 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

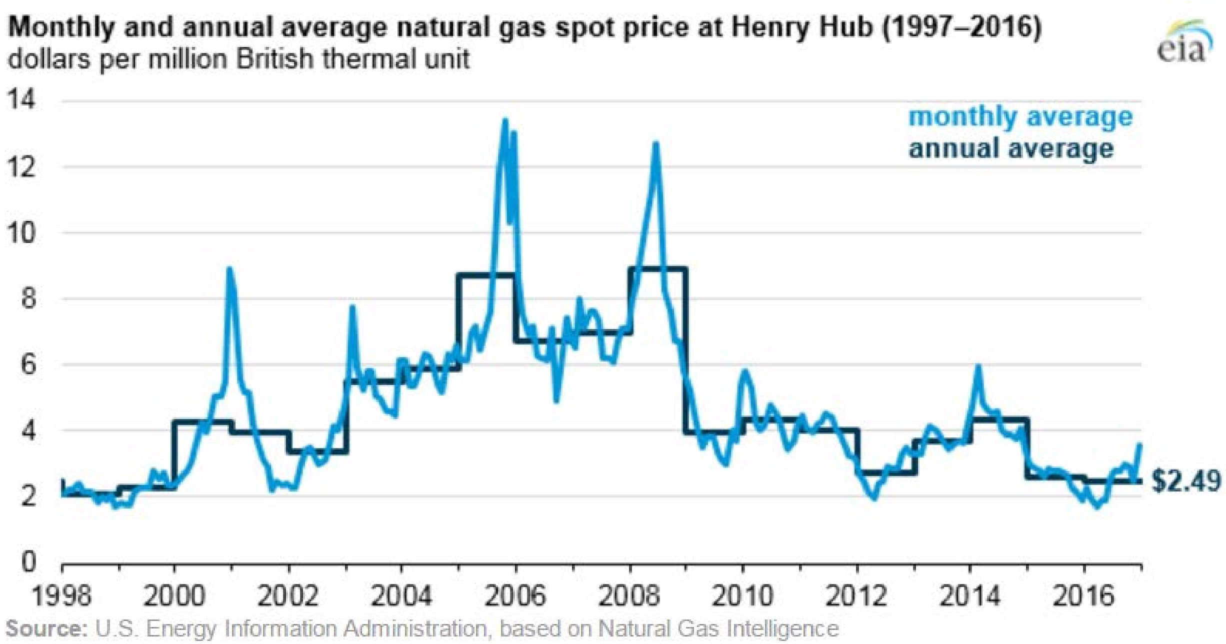
Overview of Allen Steam Station

- 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



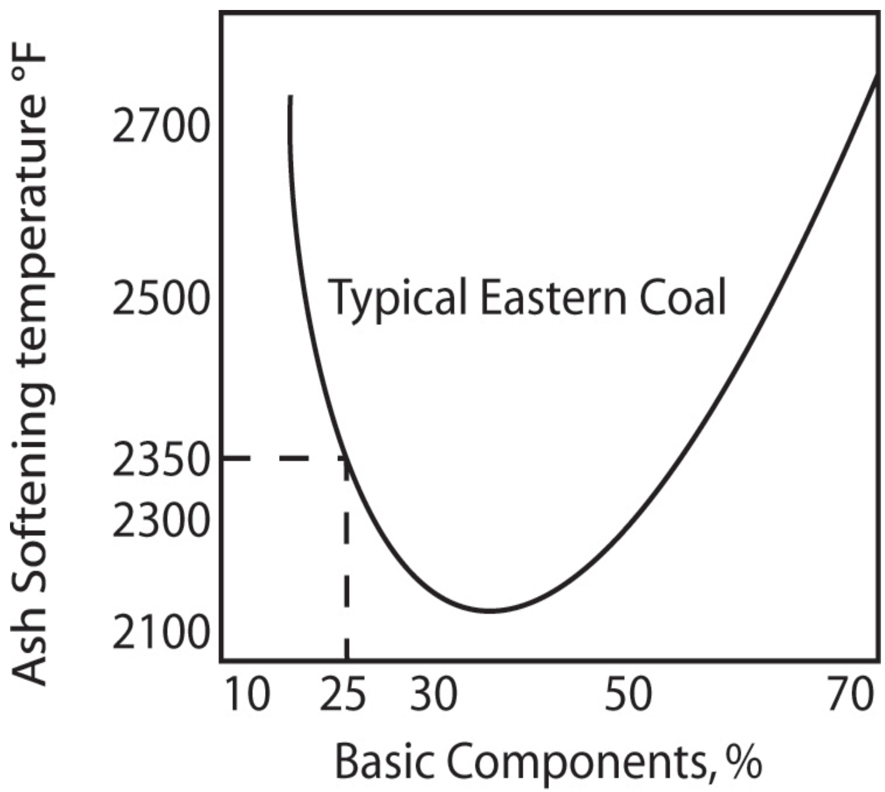
Comparison of Coals

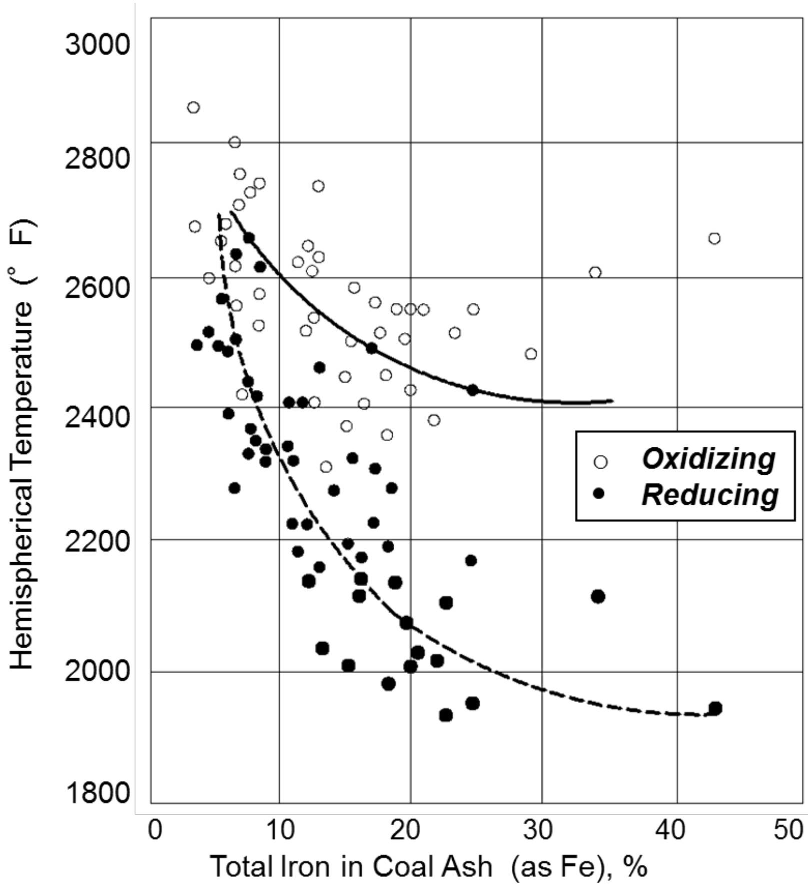
- Allen Steam Station has historically fired boiler friendly CAPP – Central Appalachian coals
- Lower cost ILB – Illinois Basin coals that were purchased were extremely boiler unfriendly
  - Sulfur content increased 262%
  - Iron content increased 345%
  - Chlorine content is 0.16% - 0.19% on average
  - 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

Description	Units	CAPP	ILB
Higher Heating Value	Btu/lb	11,525	12,287
Moisture	%	7.38	7.28
Ash	%	18.00	10.17
Sulfur	%	0.97	3.51
Volatile Matter	%	30.5	35.82
Ash Loading	lbm/MMBtu	13.96	8.28
SO_2	lbm/MMBtu	1.69	5.71
B/A Ratio		0.16	0.65
HGI		44	53
FSI		1	7.1
Oxidizing Atmosphere			
Initial Deform.	°F	XXXX	2,365
Softening	°F	XXXX	2,402
Hemisphere	°F	XXXX	2,461
Fluid	°F	XXXX	2,506
Reducing Atmosphere			
Initial Deform.	°F	2,500	1,964
Softening	°F	2,600	1,996
Hemisphere	°F	2,700+	2,064
Fluid	°F	2,700+	2,245

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

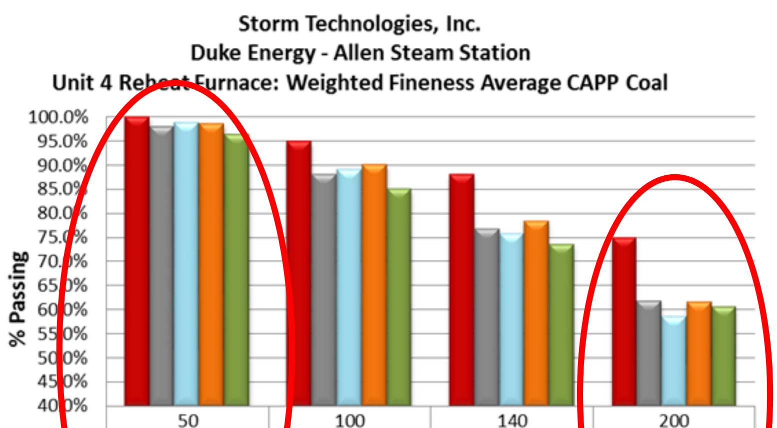
- Duke and Storm worked together to develop a plan in order to burn the challenging ILB coals
- Prior to testing
  - All auxiliary air and fuel air dampers were stroked and visually verified internally
  - To ensure complete knowledge of coal quality, "real-time" samples were collected and sent off for 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

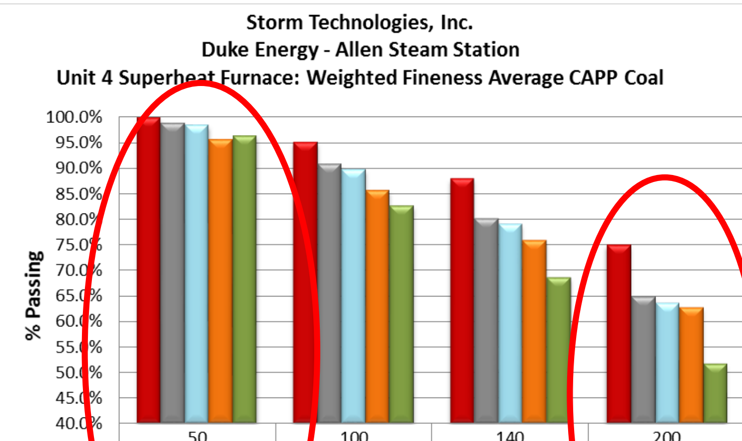
- Areas to be addressed:
  - Pulverizers:
    - Dirty Air and Fuel Balance
    - Fuel Fineness
    - Air/Fuel Ratios
  - Flue Gas Measurements:
    - Furnace Exit
      - HVT Traverses to determine FEGT's, O_2, CO and NO_X
    - Economizer Outlet
      - Traversed ducts to evaluate flue gas constituents 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



	50	100	140	200
Recommended	99.9%	95.0%	88.0%	75.0%
Mill RA	98.0%	88.2%	76.8%	62.0%
Mill RB	98.7%	89.1%	75.9%	58.7%
Mill RC	98.6%	90.1%	78.4%	61.7%
Mill RD	96.4%	85.1%	73.6%	60.8%

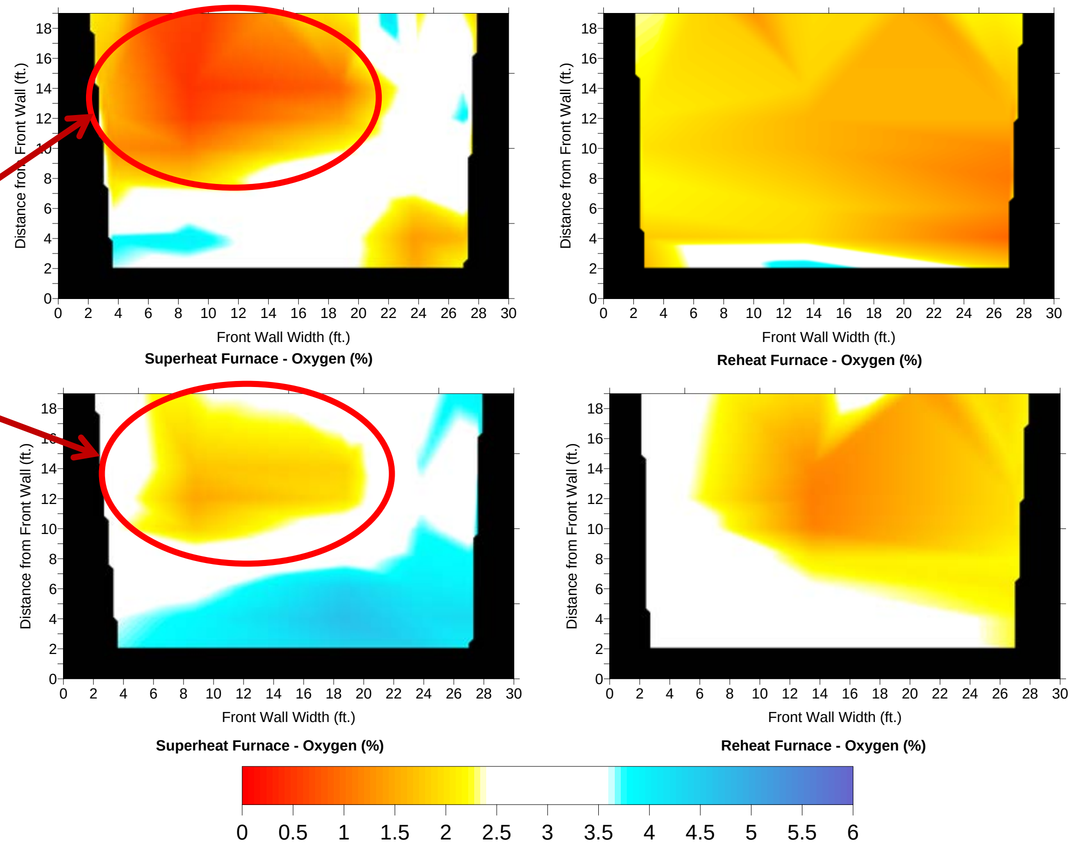


	50	100	140	200
Recommended	99.9%	95.0%	88.0%	75.0%
Mill SA	98.8%	90.8%	80.1%	64.8%
Mill SB	98.4%	89.7%	79.0%	63.6%
Mill SC	95.5%	85.7%	75.8%	62.7%
Mill SD	96.3%	82.6%	68.6%	51.6%

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

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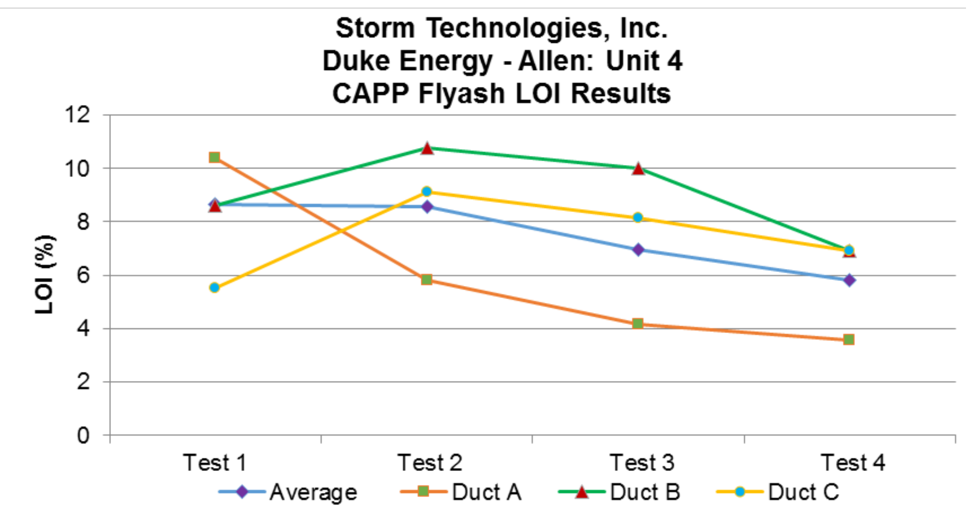
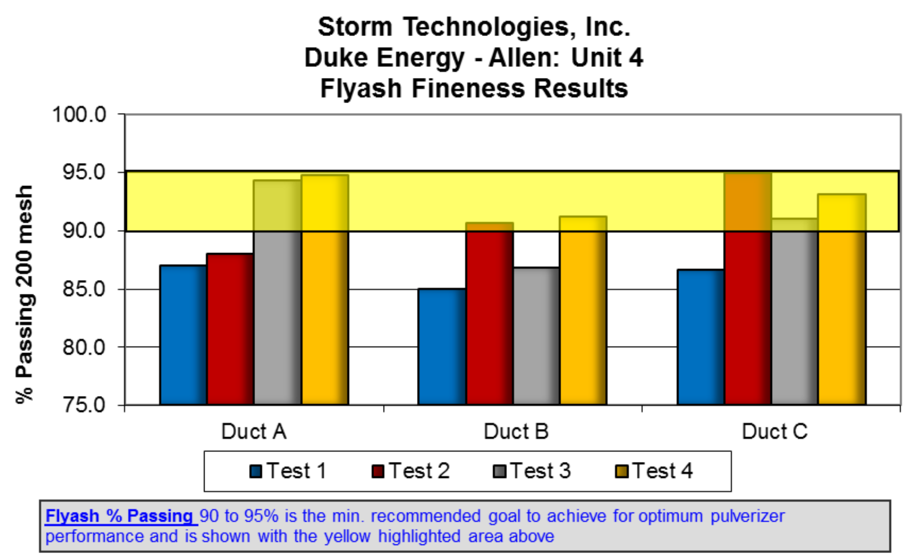
- Test results on CAPP coal
  - Flyash Analysis
    - 3-part Flyash analysis completed
      - Average fineness level 86%
      - Following classifier adjustments fineness improved to above 90%
      - LOI's improved throughout the testing/tuning on CAPP coal





ILB Test Burn Results

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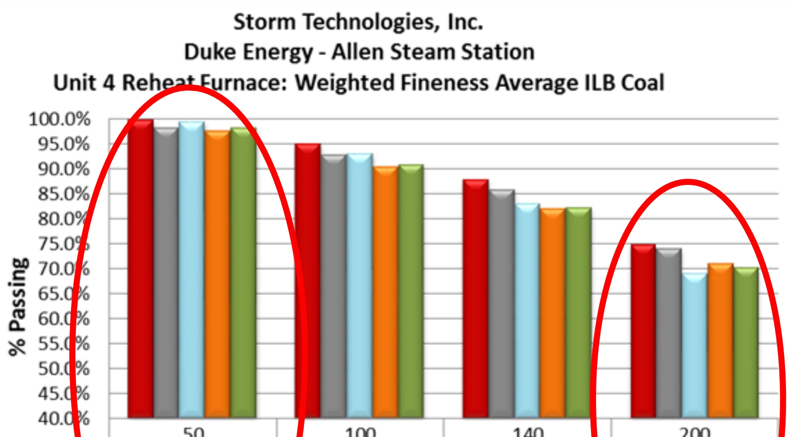
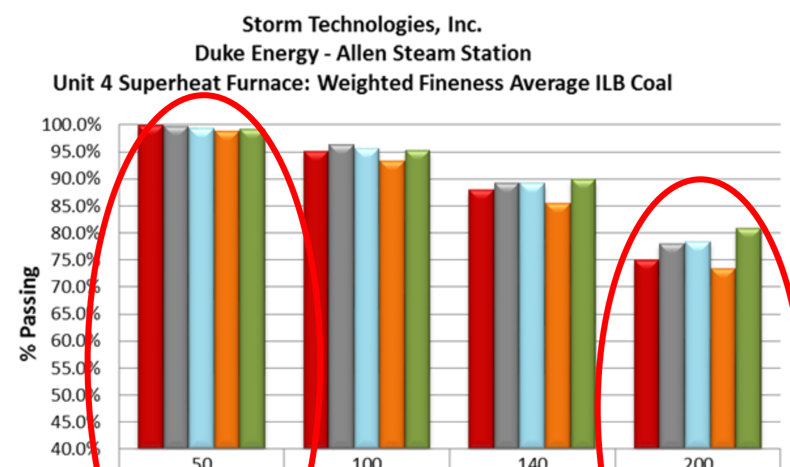
- Test results on ILB coal
  - Pulverizer performance
    - Classifiers were adjusted on 7 of 8 mills to improve fineness
    - Average of 74% passing 200 mesh
    - Average 1.2% retained on 50 mesh
    - Average mean particle size improved 26%



	50	100	140	200
Recommended	99.9%	95.0%	88.0%	75.0%
Mill RA	98.3%	92.9%	85.8%	74.1%
Mill RB	99.6%	93.0%	83.1%	69.1%
Mill RC	97.7%	90.4%	82.0%	71.0%
Mill RD	98.3%	91.0%	82.4%	70.3%

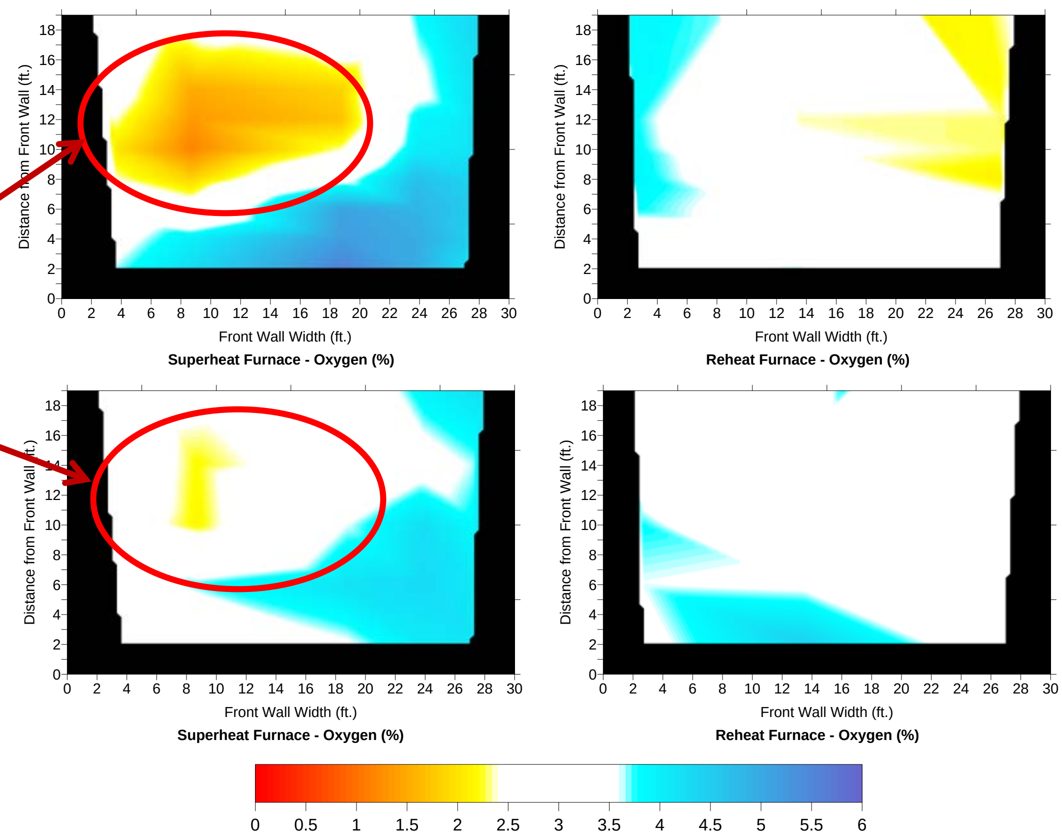


	50	100	140	200
Recommended	99.9%	95.0%	88.0%	75.0%
Mill SA	99.56%	96.2%	89.1%	78.0%
Mill SB	99.26%	95.5%	89.2%	78.3%
Mill SC	98.76%	93.2%	85.4%	73.4%
Mill SD	99.04%	95.2%	89.8%	80.8%

ILB Test Burn Results

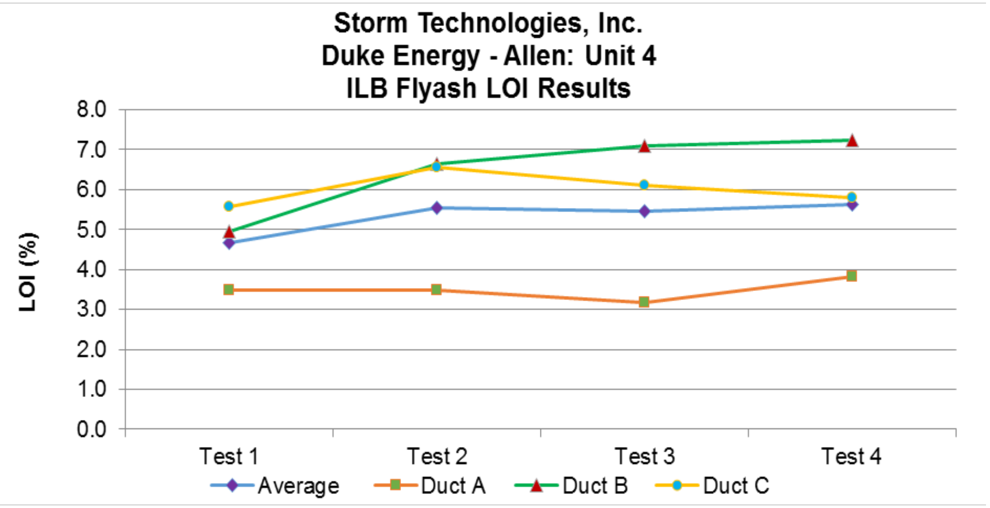
- Test results on ILB coal
  - Flue gas measurements
    - Excess oxygen bias increased to provide desired average of 3% excess oxygen
    - WB/Furnace DP's optimized to improve combustion.
    - SOFA & CCOFA's optimized for combustion and steam temperatures

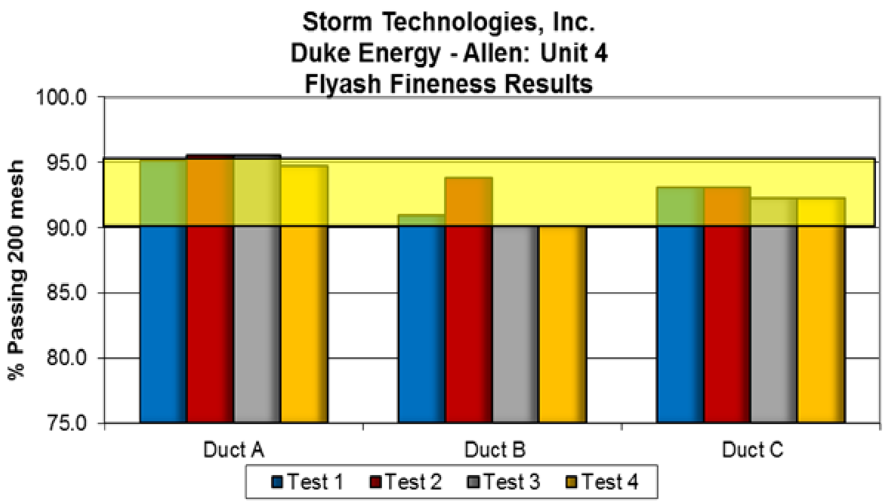
Additional Tuning Further Improved Excess Oxygen Levels and Distribution



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

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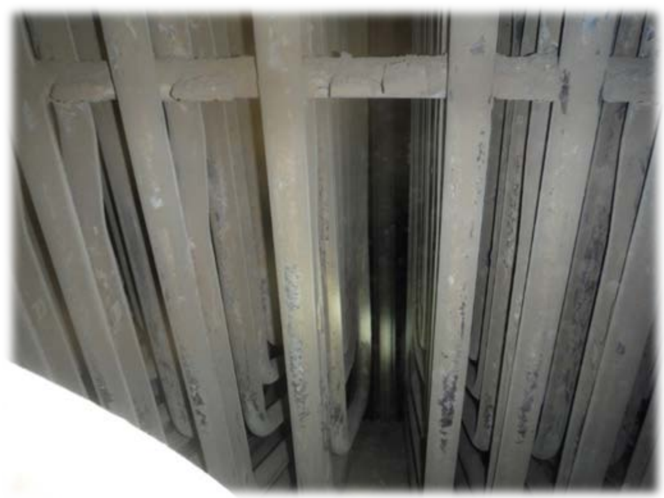
- The presence of an oxidizing environment is extremely important
- Fuel fineness levels must be optimized to minimize fuel imbalances and secondary combustion
- Aux air and Fuel air damper operation is critical to balancing in furnace excess oxygen
- Sootblower operation must be optimized (i.e. pressures and travel)
- Allen was able to successfully operate with **<u>ZERO</u>** 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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