Coal Combustion, Inc.
Understanding the Business of Coal

Utility Experience Using NPRB Coals
Presented at the 2017 PRB Coal Users Group
Chicago, IL
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Written Summary by Rod Hatt

Introduction

Rod Hatt is the President of Coal Combustion, Inc., CCI. He specializes in coal quality impacts on power plant performance.

Dominic Martino is an engineer at Detroit Edison, DTE, where he is a Mill and Gear system SME, along with scrubber and combustion expertise.

Northern PRB coals

The Northern Powder River Basin (NPRB) mines are in Montana, Southern PRB mines are in Wyoming.

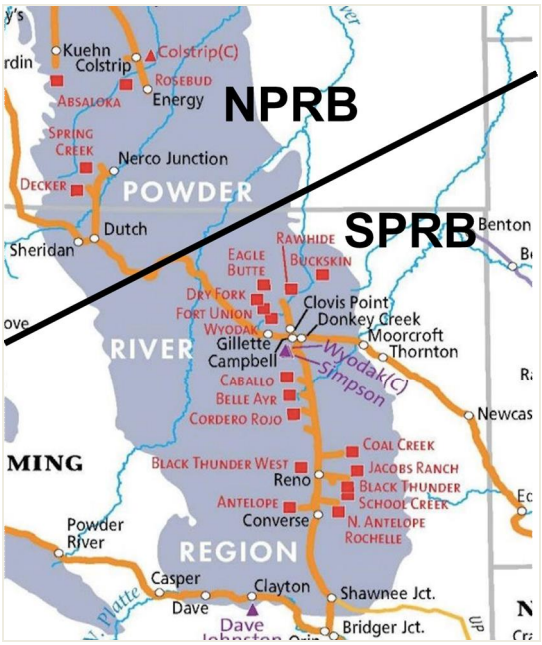

Figure 1. Location of PRB mines split between NPRB and SPRB

NPRB TO SPRB Coal Quality Comparison

Antelope (SPRB)
Spring Creek (NPRB)

Btu/lb

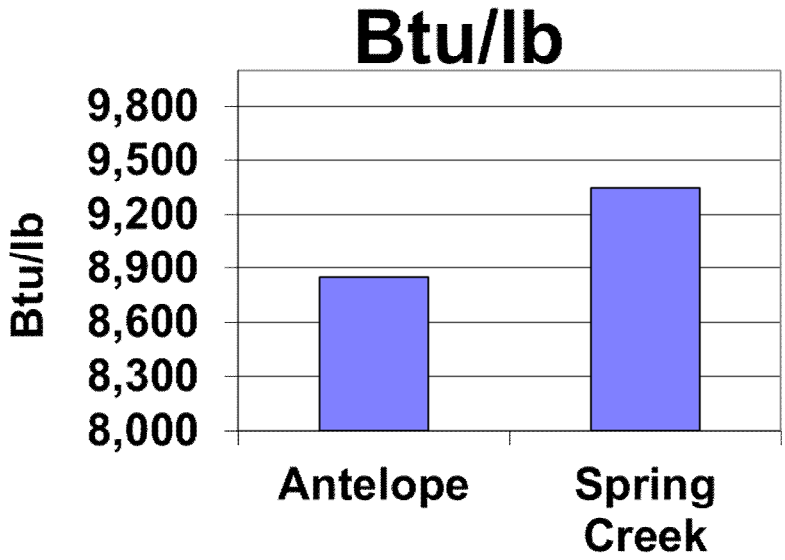

Figure 2. Spring Creek has higher calorific value, Btu/lb.

Pulverizer Capacity

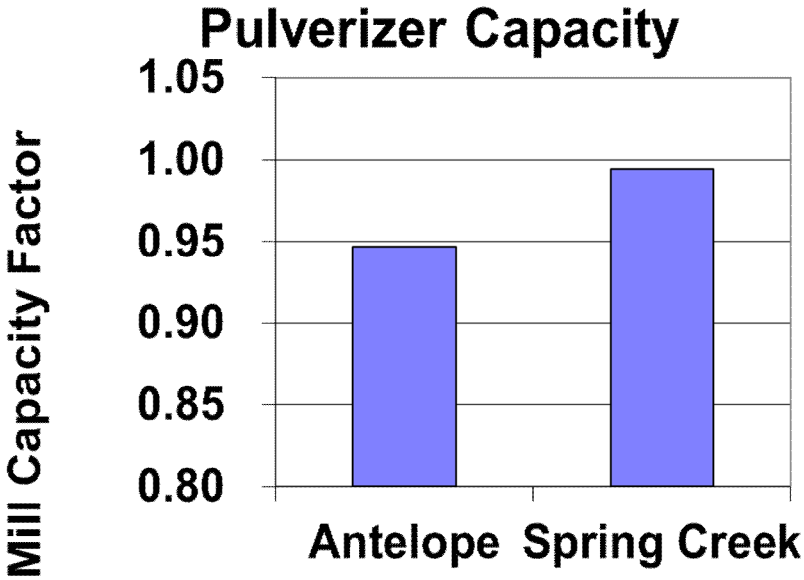

Figure 3. The higher heating value increases mill capacity at same HGI.

% Sodium

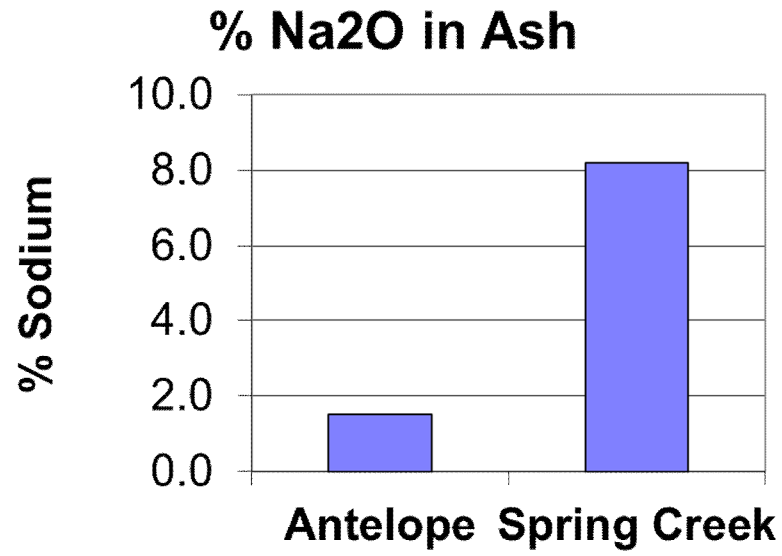

Figure 4. The sodium is higher in the Spring Creek coal.

Calcium and Iron

Calcium and iron can play a role in ash deposits, the Spring Creek is lower in these elements reported as loading levels, Lbs Element/MBtu.

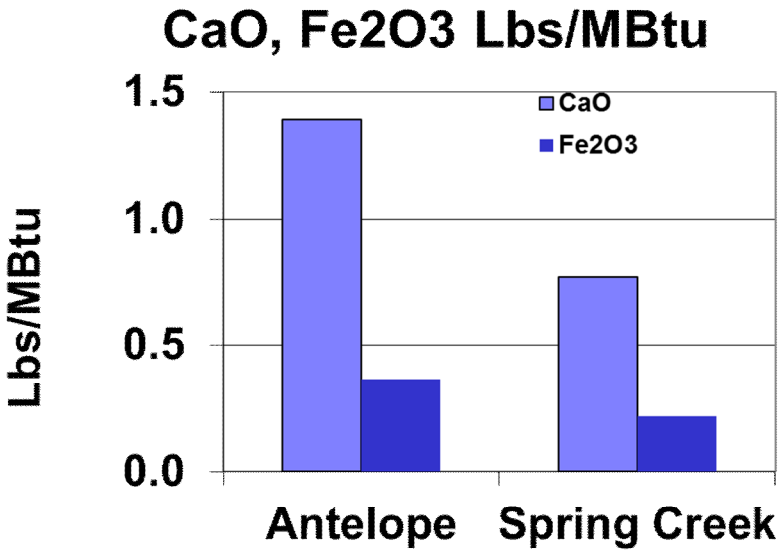

Figure 5. Calcium and iron levels are lower in the Spring Creek coal.

Organic Sodium

The sodium in the coal is mostly attached to the *coal* via an ion exchange bonding; this is termed organically associated sodium. The ASTM methodology reports the sodium as a percent Na2O in ash, but the sodium is not in the ash.

The geological conditions of the coal deposit impacts the sodium levels in the coal. The coal deposit acts like an ion exchange resin, similar to water softener resin. The active sites have sodium on them. If the roof or rock just above the coal is both permeable and rich in calcium, calcium rich water flow through the coal replacing the sodium with calcium. If the rock just above the coal seam is impermeable, the coal remains high in sodium.

These elements, typically sodium and calcium, due to their bonding to the coal, are called organically associated elements.

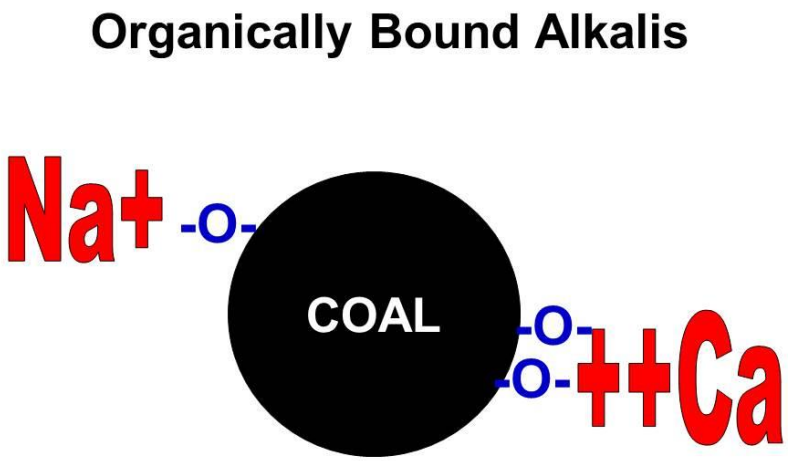

Figure 6. Sodium and calcium are bound to coal rather than in rock form.

The rock material, or out of seam dilution, OSD, is typically is low in sodium. This nature of the form of sodium in coal makes so that cannot be removed by coal washing or mining methods that minimize ash levels. It does mean that the percent sodium in the ash can be diluted by producing higher ash coal.

Volatilization and Condensation of Sodium

Sodium volatizes in the coal flame due to it being attached to the coal matrix, it then condenses on the fly ash leaving the flame causing the fly ash to become sticky. This sticky ash can build up deposits on the steam tubes (convection pass) plugging the gas passage and usually results in a boiler outage to clean it off. These types of deposits are usually called Fouling Deposits, as opposed to Slagging or furnace wall deposits.

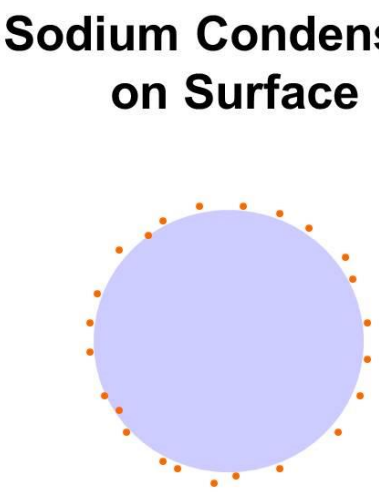

Figure 7. Sodium condenses on fly ash after volatilizing in the flame.

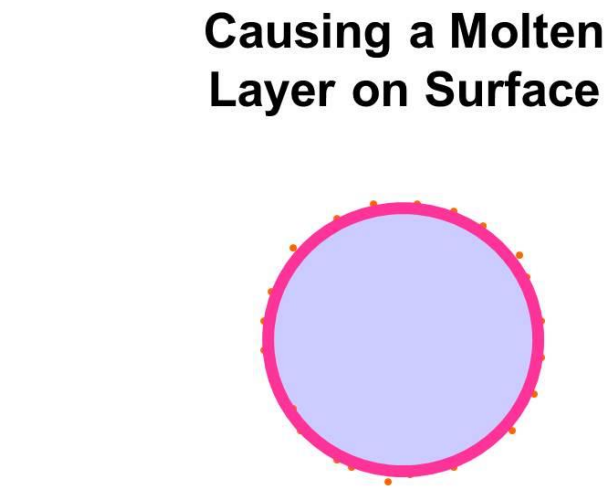

Figure 8. The sodium fluxes the surface of the alumino silicate fly ash, making the surface sticky.

FEGT and the Issues

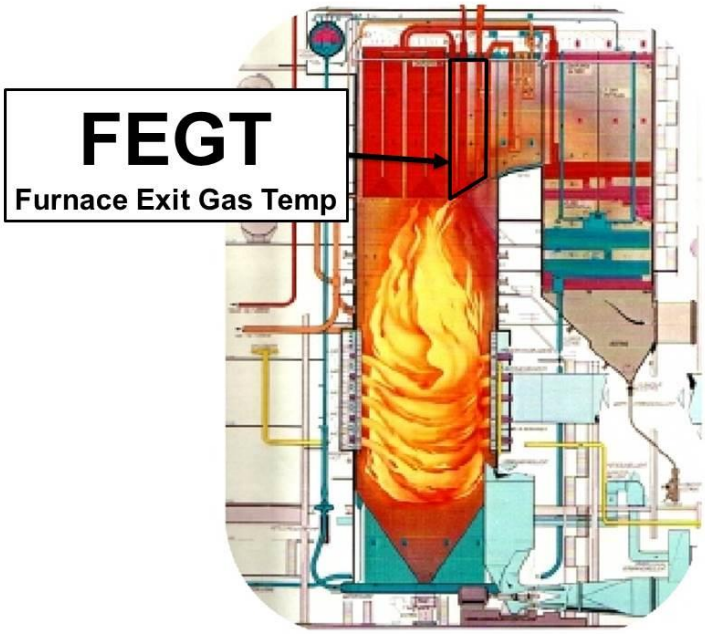

Figure 9. The higher the furnace exit gas temperature, FEGT, the stickier the ash. FEGT should be controlled and minimized.

Steps used to Utilize NPRB

Boiler Design

Many of the existing US boilers that switched to low rank (sub-bituminous and lignite) Western US coals have had problems with pulverizer capacity due to the high moisture and low heating values compared to their design coals. One solution for this is to not grind the coal as fine, therefore increasing pulverizer capacity. This improves the pulverizer limitations, but is a well-documented cause of ash deposits. This presents an issue for us and boiler manufactures in sorting out what is causing the ash deposits.

A boiler designed for the use of low rank fuels has the pulverizer capacity needed for fine grinding. This section looks at furnace and convection pass designs for higher sodium coals, rather than the pulverizer issues.

There are two main features of a boiler designed for higher sodium coals,

1. Low furnace exit gas temperature (FEGT)
2. Wider convection pass tube spacing

These parameters can be designed when a new boiler is built. The two large boiler manufacturers: Alstom (CE), and Babcock and Wilcox (B&W) have extensive experience with higher sodium coals and can build a new boiler with no issues. This experience is well documented and should be available for other boiler manufactures that have less experience.

These two items, low FEGT, and wider tube spacing can also be applied to existing boilers.

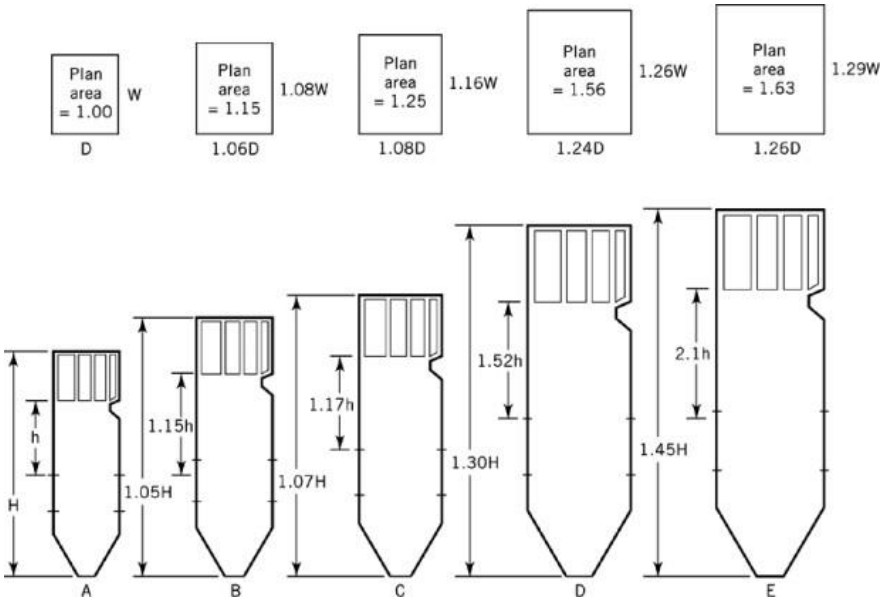

Figure 10. Small boilers like A and B are suitable for oil and CAPP type coals. Boiler size C and D are better suited for ILB and PRB coals. Large size E boilers are used for Lignites.

Additional Cleaning Equipment

There have been vast improvements in the design and types of deposit cleaning equipment. These include water cannons and hydro jets designed to keep the furnace clean and lower the FEGT. Other improvements include multimedia ï air, steam, and water retractable soot blowers.

Utilities continue to replace older soot blower designs with these newer designs adding effectiveness to the cleaning. Additional cleaning equipment can be added to areas where deposits form to keep these areas clean. This is a relatively low cost modification.

Use of Water media
Additional Retracts
Additional Wall Blowers

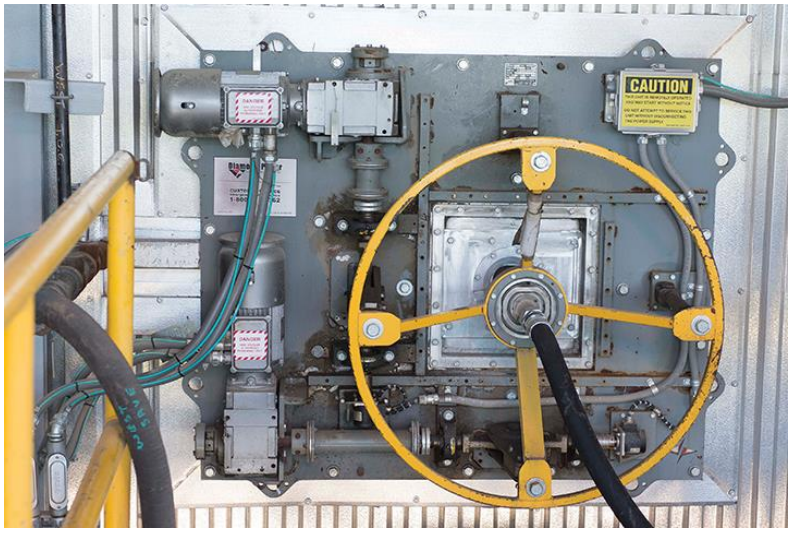

Figure 11a and 11b. Water based water wall cleaning equipment.

Utilities have several operational options that can both lower FEGT and be more proactive in how they operate cleaning equipment. Lowering the FEGT can be accomplished by improving combustion, and cleaning the furnace water walls. Both major soot blower manufacturers (Diamond Power, Clyde Bergman) can provide computer controlled soot blowing programs that can automatically improve cleaning effectiveness. Installation of water based water wall cleaning equipment, both manufactures offers this equipment, can greatly assist in lowering FEGT.

Utility Experience

St Clair and Belle River Plants

Figure 12. Belle River plant in foreground, St. Clair plant in background.

Using NPRB Since the late 1970's
Blends with Pitt #8 NAPP coals
NPRB main component of blends
Over 60 million tons used in last 10 years

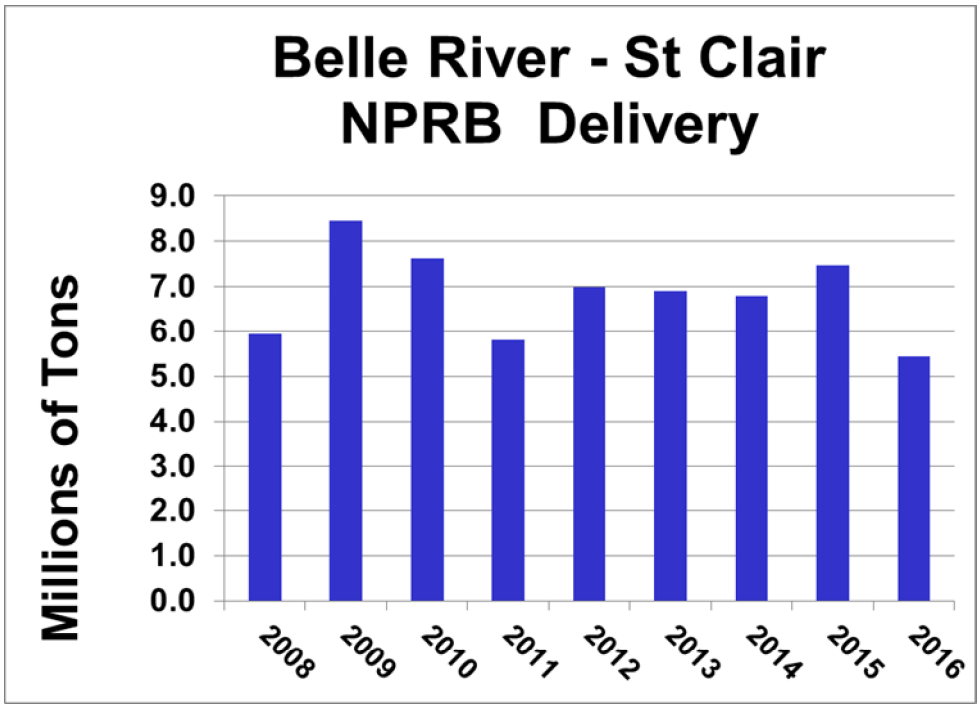

Figure 13. Past NPRB deliveries

Classes of Slagging/Fouling

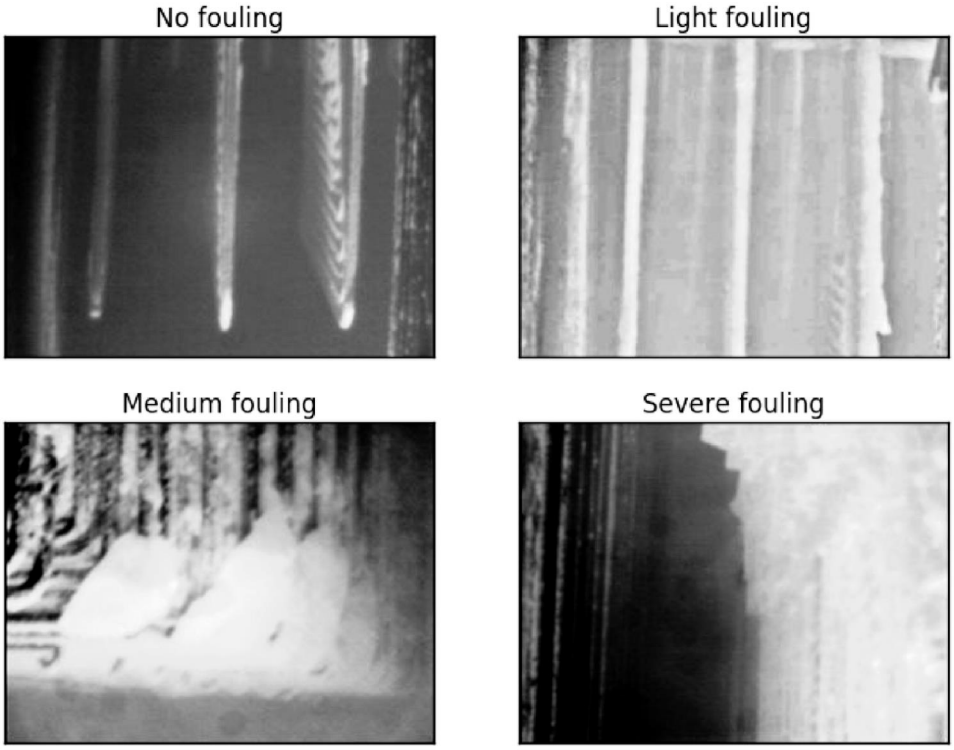

Figure 14. Fouling photos with degree of fouling indicated.

Modify Operations

Measure & Control FEGT
- Higher NOx Tuning
- Finer Coal Sizing
- Clean Water Walls

Load Drops
- Planned
  - Deslag
  - Low Load Soot Blowing
- Forced

- Deslag pre-specifications
  - Load shed from X > 640 GMW to X < 400 GMW
  - Ramp rate > 3 MW per minute

Figure 15. What a slag sheading load drop looks like.

Quiz

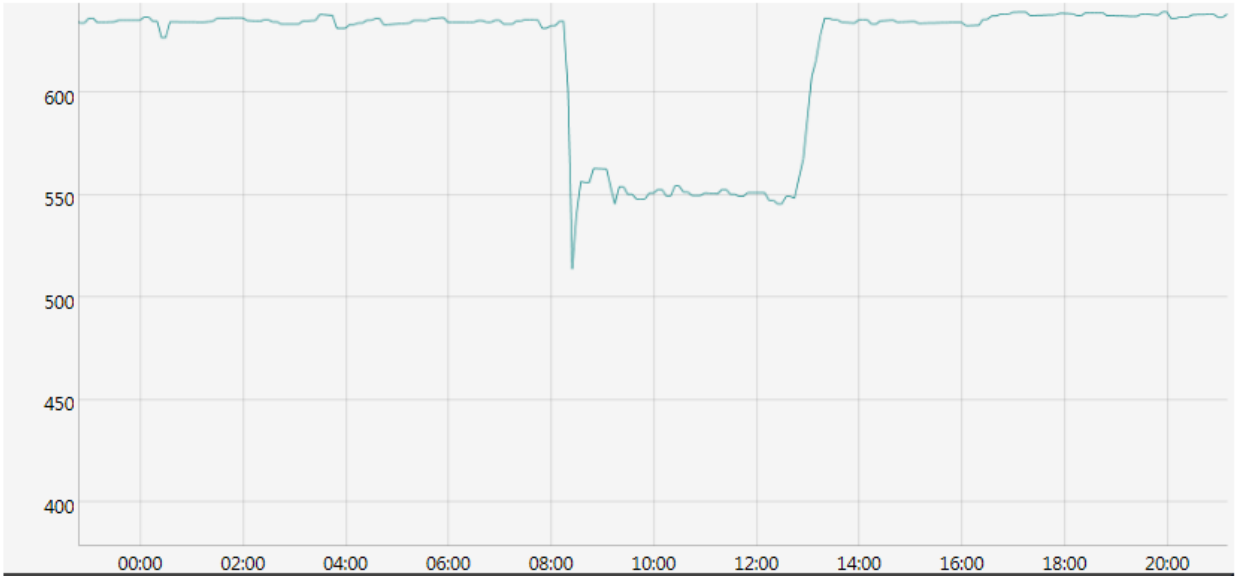

Figure 16. Not a slag sheading load drop, just a load drop.

Deslag Benefits

Run Duration O&M Costs Heat Rate

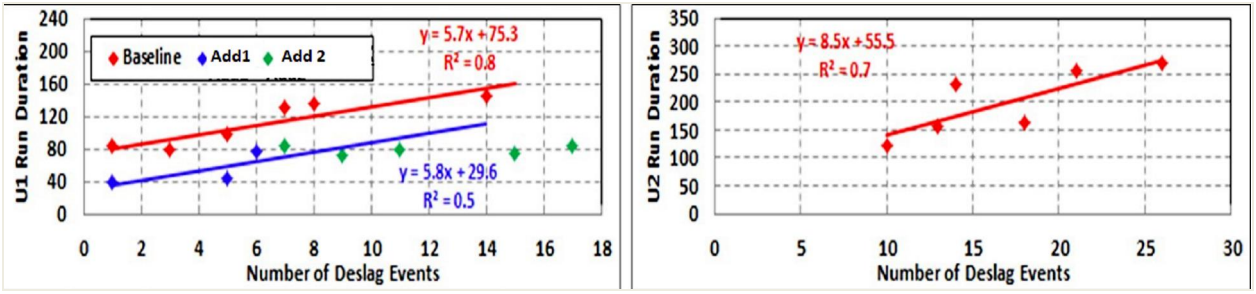

Figure 17. Impacts of deslagging on run time, additives did not solve issues.

Same effect with or without additive
Slope is a guide for frequency

Key Performance Indicators

- Different runs, same pattern
- KPI, Measure performance
- Deslag Impact : 1) lower DP 2) Flatter slope

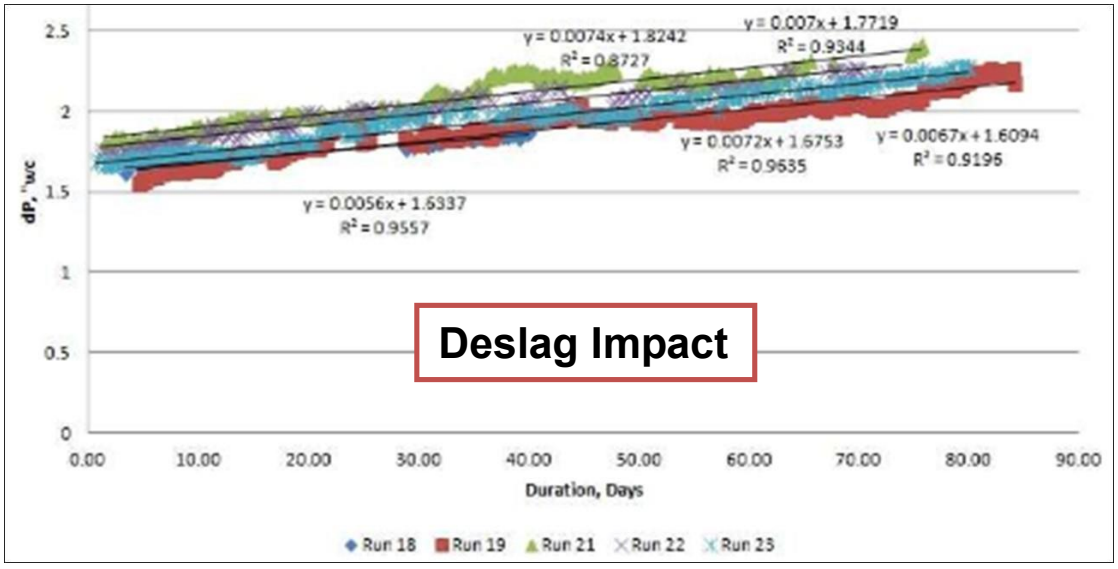

Figure 18. Impacts of deslagging on dP across tube banks.

Modify Operations

Dilution of Sodium with Ash

Since the sodium is in the coal, ash levels impact the % sodium in the ash. Higher ash results in lower sodium %, low ash results in higher values. Typically, doubling the ash results in half the sodium percentage, due to dilution by the ash. Experience suggests that this helps minimize the sodium bonding. The sodium bonding results from the layer of condensed sodium on the fly ash that can melt the outside of the ash, making it stickier and more likely to make deposits.

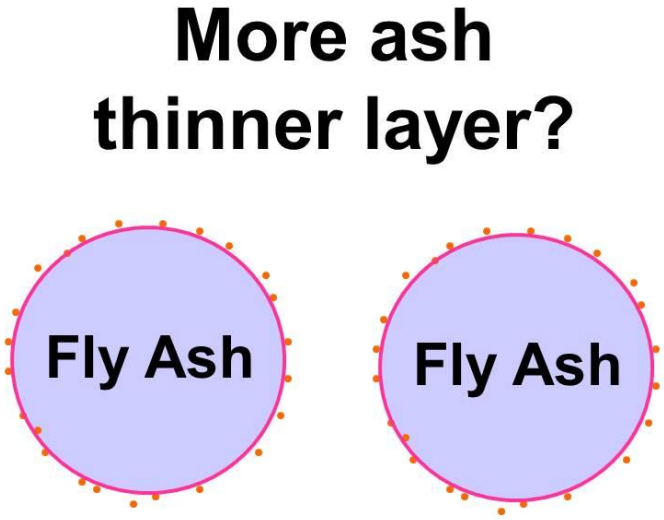

Figure 19. Can more ash dilute sodium, yes but it takes considerable ash increases.

The thickness of this molten layer is proportional to the stickiness. If more ash is added to the coal, and the sodium remains the same, a thinner layer of sodium results.

It has been shown that the stickiness of higher sodium coals can be decreased using more ash to dilute the sodium percentage. The best case is the Centralia plant in Washington State where this method of reducing issues has been used

for years. The use of high aluminum clay like material is more effective than silica rich forms of material. This can increase the ash levels significantly, so there can be costs and performance issues associated with higher ash levels.

Another common way to express sodium levels is the use Lbs Na_2O/MBtu. This looks at sodium levels more the way a boiler sees the sodium and takes away the ash dilution impacts.

Lbs. of ash/MBtu
= %ash / (Btu/10,000)

Lbs. of element/MBtu
= %ash / (Btu/10,000)
X (%Element/100)

Test	Hi Na_2O	Low Na_2O
Btu/lb	9,300	9,000
% Ash	4.0	6.5
% Na_2O	8.0	5.0

Test	Hi Na_2O?	Low Na_2O?
lb Ash/MBtu	4.3	7.2
% Na_2O	8.0	5.0
lb Na_2O/MBtu	0.34	0.36

Figure 20. Example of how % sodium can be diluted, but Lbs Na2O/MBtu is not.

Fuel Side additives

There are several suppliers of fuel additives that make claims of their effectiveness. One of the most promising uses a clay based additive designed to capture sodium and potassium before they cause excessive deposits. This is in line with the Centralia experience, but less additive is needed than mine added material. This could also provide a low capital means of minimizing deposits. It is not uncommon to have the additive supplier supply the equipment with no capital costs. There may be costs involved like supplying

water and power to the equipment. Additive suppliers typically price the product just below other alternatives so treatment cost can approach $0.10-$2.00+ per ton of coal treated. Some utilities have included this in fuel costs, so there is no direct cost to the plant.

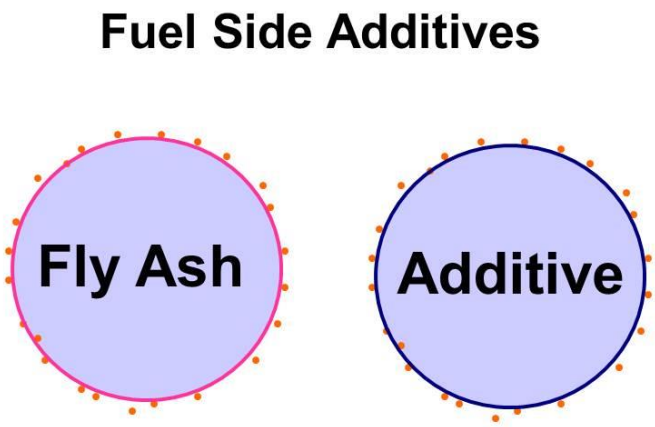

Figure 21. Fuel side additives my work like additional ash, maybe they could be more resilient to the sodium than the fly ash.

Fuel Blending

Blending with Lower Na2O Fuels

Many qualities can be blended
Increases range of coal qualities considered
Use Loading values rather than laboratory
Poor qualities can be minimized by blending with offsetting qualities

Most coals and other carbon based fuels have low sodium levels. These include: natural gas, oil, Southern PRB, and mast all bituminous coals. Most all boilers can take some high sodium coal if it is blended with lower sodium fuels. The amount of higher sodium coal in the blend is very plant specific, and can range from a few percent to over ninety. Typically blend ratios are based on plant experience, rather than predictive methods.