Coal Quality
As the Boiler Sees It

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Short Prox

**Moisture** – total moisture in sample

**Ash** – inorganic rock like material remaining after complete combustion

**Sulfur** – total sulfur in sample including organic, pyritic, and sulfate

**Heating Value** – higher heating value (HHV) of coal expressed as Btu/lb. British thermal unit (Btu) is the amount of energy needed to raise one pound of water one degree F.
Ultimate Moisture, Ash, Sulfur – as described

**Carbon** – total elemental carbon

**Hydrogen** – total elemental hydrogen not included in moisture, (fuel hydrogen)

**Nitrogen** – total elemental nitrogen

**Oxygen (by difference)** – remaining major element calculated by summing moisture, ash and elements listed above and subtracting from 100
Ash Chemistry
Major & Minor Elements

SiO2  Fe2O3
Al2O3  CaO
TiO2  MgO
      K2O
      Na2O
Boilers want Heat.
We know this because operators say things like:

- We’ll add some heat
- We’re pour’n the coal to her
- Burn Baby Burn
- Get her Hotter
- Add Fuel to the Fire
- We increase the fire
- Let’s get things heated up
- We burn coal
- Hunka, hunka Burning coal
- Let’s stoke her fire
- Poke those embers
- We heat it up
- Stoke’m up baby
- We’re going to make it real hot
We understand the concept of buying Btus by pricing fuels In:

$$\$/\text{Mbtu} = (\$/\text{ton}) / 2x(Btu/\text{lb}/10,000)$$

Example:

$40/\text{ton} \quad 12,500 \text{ Btu/lb.}$

$$\$/M\text{Btu} = (40)/(2x(12,500/1,000))$$

$$\$/M\text{Btu} = (40)/(2\times12.5)$$

$$\$/M\text{Btu} = 40/25 = \$1.60 \text{ per MBtu}$$
We understand the concept of buying Btus and,

Boilers want heat.
Lets look at all boiler related coal qualities on a heat basis; lets put all percentages on a per million Btu basis

LOADING LEVELS
The industry has used SO$_2$ emission levels expressed in lbs SO$_2$/MBtu for over 20 years.
ESP performance is based on the lbs Ash/MBtu, Ash Loading, not percent ash.
May slagging concerns have been addressed using Ash Loading and Elemental loading levels; especially \( \text{Fe}_2\text{O}_3, \text{CaO}, \text{Na}_2\text{O} \)
Ash Loading and Elemental Loading

Ash levels

Ash levels in coal are generally reported from the lab as a percent of ash. This is convenient for the lab but not completely representative of what the boiler sees. Boilers demand Btus, not tons of fuel. A more representative (for the boiler) way to express ash levels is to use pounds of ash per million Btu. These units are easy to calculate using the following expression:

Lb. Ash/MBtu = %Ash/(Btu/lb./10,000)
The author has on numerous occasions found that the ash deposits formed in utility sized boilers correlates best with ash and elemental loading data, rather than fusion temperatures or traditional slagging and fouling indices.

**Basic or Bonding Elemental Loading**

**Pounds of iron per million Btu**

**Pounds calcium, sodium, and other elements**

The coals are then compared on a total ash and elemental loading level basis. This procedure works well as indicated in the example below, only if the combustion system is tuned up and there are not excessive carbon and combustion issues.
Slagging with Bituminous Type Ash - High Iron

This example will show how a utility was able to lower its ash fusion specification by understanding how different coals behave in the boiler. Typically utilities have specifications for total ash (in percent) and a fixed fusion temperature spec. Published accounts of utilities experience in this area have led many slag specialists to consider the amount of ash loading to be important. When ash levels are expressed in pounds per million Btus, they more closely reflect the levels seen by the boiler. The author has also proposed that the iron loading (lbs. Fe2O3/MBtu) level is an important consideration. In several Eastern/ Midwest US coal slagging events worked on by the author, the problematic coal had elevated iron loading levels.
Using this information several utilities have conducted test burns of coals with lower fusion characteristics. Their strategy was to limit the iron loading by considering lower ash, higher iron coals. These coals had lower than design fusion temperatures but it was suggested that the lower ash levels would offset this. The results of the test confirmed that the iron loading levels more accurately predicted the slagging behavior of the coal than the fusion temperature of the coal.
Experience suggests that rating PRB coals using calcium and sodium loading levels correlates better than fusion temperatures.
Coal Reactivity

Volatile Fuel Ratio, FC/Vol
MAF Oxygen C/H
HGI and others
Coal Reactivity
Consider:
Volatile Oxygen
per million Btus
Boilers want Heat.