10911 Technology Place
San Diego, CA 92127, USA
Tel: +1-858-217-2200
Fax: +1-858-217-2203
www.sabiainc.com
NRC License # 11-27727-01

A Report on an Investigation into SABIA's Ability to Provide a Coal Heating Value Analysis Utilizing Carbon

by Steve Foster
October 3, 2014

Background

Beginning in 2000 SABIA began shipping PGNA based analyzers to the customers who processed coal. From the outset, SABIA's approach for delivering a heating value reading to the customer was a moisture, ash dilution approach based on the following equation:

CV = MAFCV * (100% - Ash% - Moisture%)

Where CV = Calorific Value
MAFCV = Moisture Ash Free Calorific Value

The model makes works because coal is comprised primarily of Carbon, Ash, and Moisture. Since the majority of the energy derived from burning coal comes from the combustion of the carbon it stands to reason that any dilution of the carbon by ash or moisture would affect the calorific value. This equation works well and has proven itself many times in the field. In fact, over a wide range of coal ranks this approach has proven itself superior to all other PGNA approaches. It requires the use of historical data for any given coal type to ascertain the MAFCV for use in the equation.

It has been known for quite some time that by using ultimate analysis laboratory data the calorific value for coal can be approximated using equations like the one developed by Petit and Dulong ash shown below:

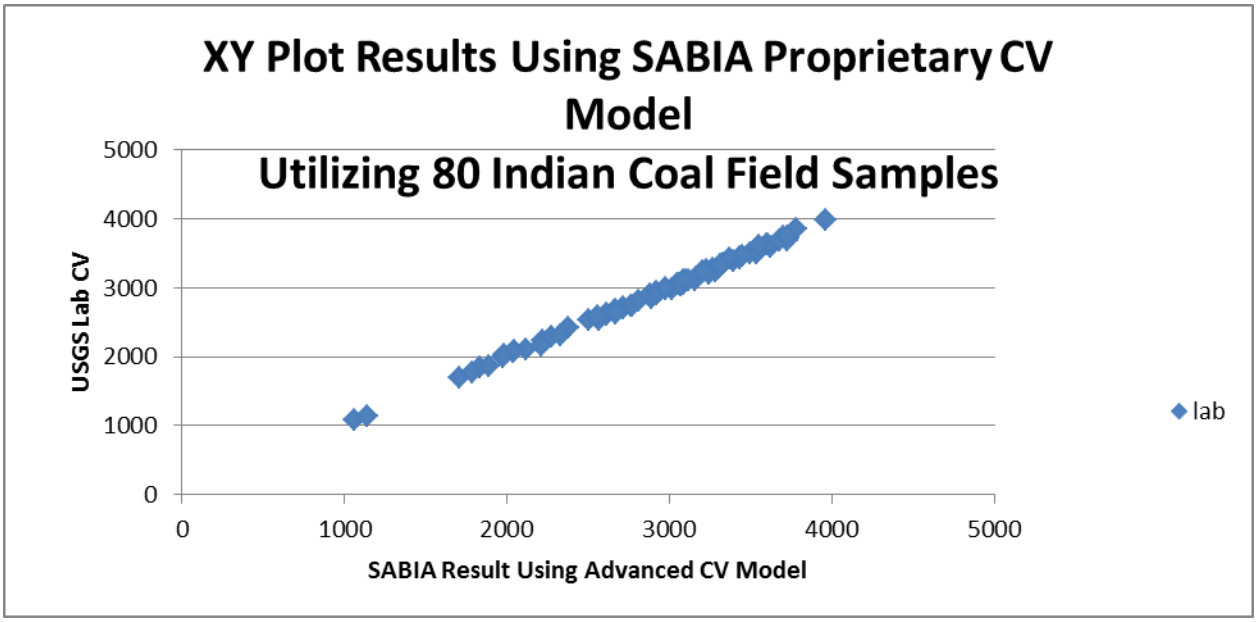
CV = 337C + 1442(H - O/8) + 93S (Note: There are many variations on this basic equation)

The results obtained with such an equation using laboratory data are effective although all the terms in this approach are not completely logical from a physics perspective. As the accuracy and precisions of PGNA analyzer technology has improved over the years it has now become possible for companies that provide PGNA analyzers to the coal processing companies utilizing a caloric reading based on equations such as this. This paper documents the results of SABIA's search for a superior calorific value analysis utilizing carbon as well as other measured parameters available during the analysis of coal. It should be noted that despite the claims to the contrary by some vendors of PGNA analyzers both approaches, both the moisture ash dilution and the Petite Dulong equation approach do not constitute a direct measurement of calorific value, but rather a calculation of calorific value based on directly measured parameters that are proportional to calorific value.

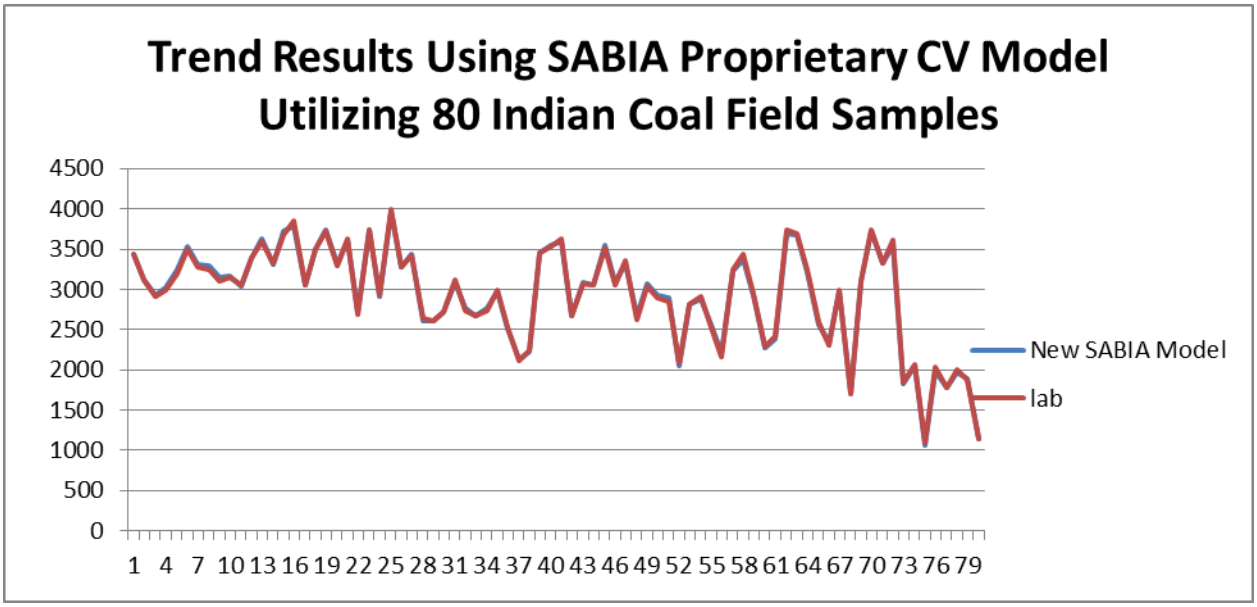
Developing a Robust CV Model Using a Comprehensive USGS Coal Data base

SABIA began its investigation of the use of a measured carbon reading as part of the basis for a calorific value (CV) reading delivered to the customer by looking at various models for CV using a comprehensive data base with ultimate analysis. The data used was taken from the United States Geologic Survey website. It is a twenty five (25) megabyte excel spreadsheet, entitled WoCQI_v1_1 created on January 8, 2008, containing over one thousand five hundred eighty two (1582) data points from fifty three (53) countries, from Afghanistan to Zimbabwe. The data is varied with samples from a wide variety of coal fields, even within each country. For this study attention was focused on the data from eighty data points of Indian coal, taken from 10 different coal fields, including both bituminous and lignite coal.

The goal in using this data was to confirm that a Petite Dulong equation would work and then to see if a better, more realistic from a physics point of view, could be developed. The data did confirm the validity of a Petite Dulong type equation, but it also confirmed that another significantly better equation would lend itself to use by SABIA. The new model yielded a correlation coefficient of 0.99 with a standard error of 49.3 kcal/kg. The result of using this equation with the USGS data base is shown below:



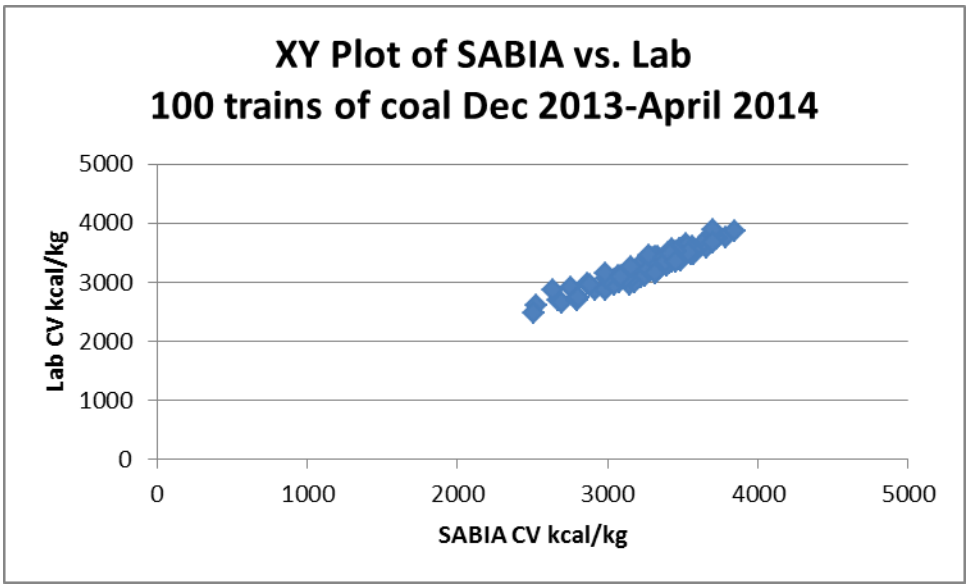
10911 Technology Place
San Diego, CA 92127, USA
Tel: +1-858-217-2200
Fax: +1-858-217-2203
www.sabiainc.com
NRC License # 11-27727-01

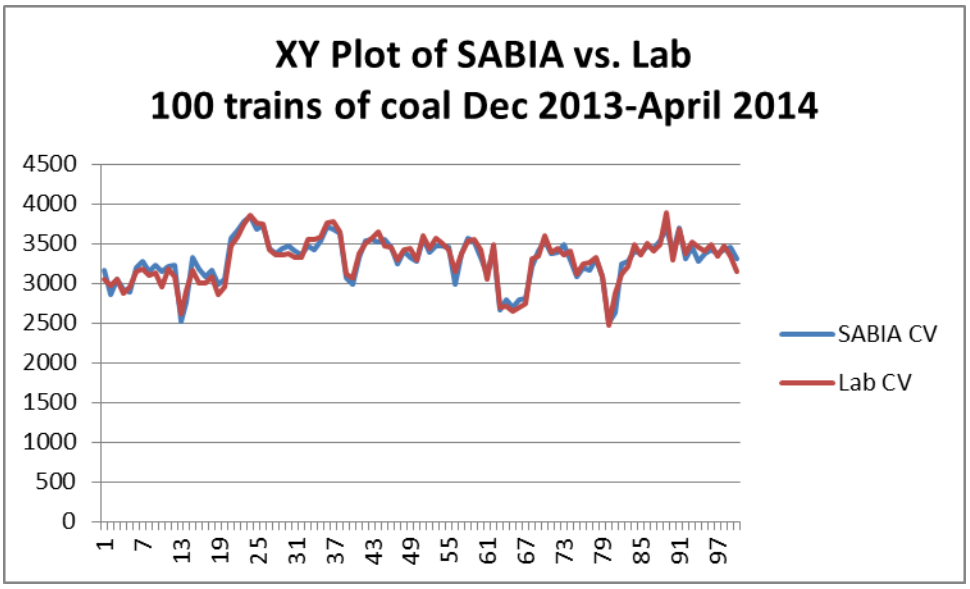


The work with the USGS data base of Indian coal confirmed both that a measurement approach utilizing a carbon reading from the analyzer could work and also that a model significantly better than the Petite Dulong equation would work with the SABIA analyzer. Next it was important to explore actual SABIA site data to confirm the effectiveness of the model.

Validating the New CV Model Using Field Data

For the field data a site with a SABIA coal analyzer looking at coal being loaded into trains was used. This site was chosen because it had already been proven that the site mechanical sampler took good, representative samples and that the associated lab was precise and accurate. The data base used consists of measurements on the coal placed in one hundred (100) trains from December 2013 through April 2014. The same proprietary formula developed using the aforementioned USGS database was applied to the data for these one hundred (100) trains with a CV range from 2500 to 4000 kcal/kg. For this body of data the SABIA analyzer achieved a correlation coefficient of 0.91 with a standard error of 87 kcal/kg. The results are shown below:





Conclusions

The data shows conclusively that the SABIA PGNA analyzer utilizing our new proprietary CV model incorporating a carbon measurement can deliver effective real time measurements of CV to our customers. We are now prepared to offer CV RMSD performance on a one hour basis of 100 kcal/kg to our customers around the world. It is to be understood by all of SABIA's customers that the ability to quantify this kind of high precision, robust performance will require calibrated, unbiased samplers and ASTM level quality from the associated labs.