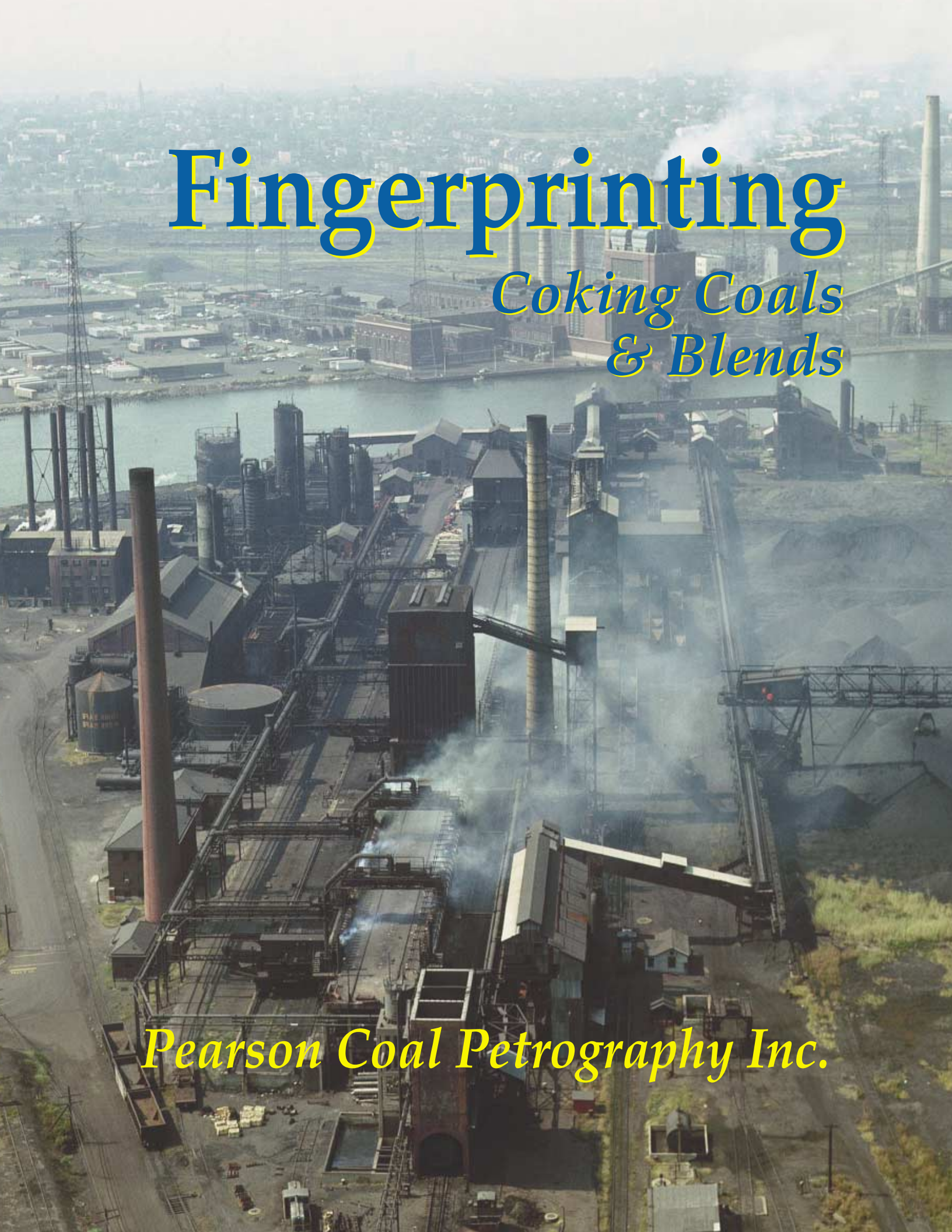


Fingerprinting

Coking Coals & Blends

Pearson Coal Petrography Inc.

Microscopic Fingerprinting of Coal

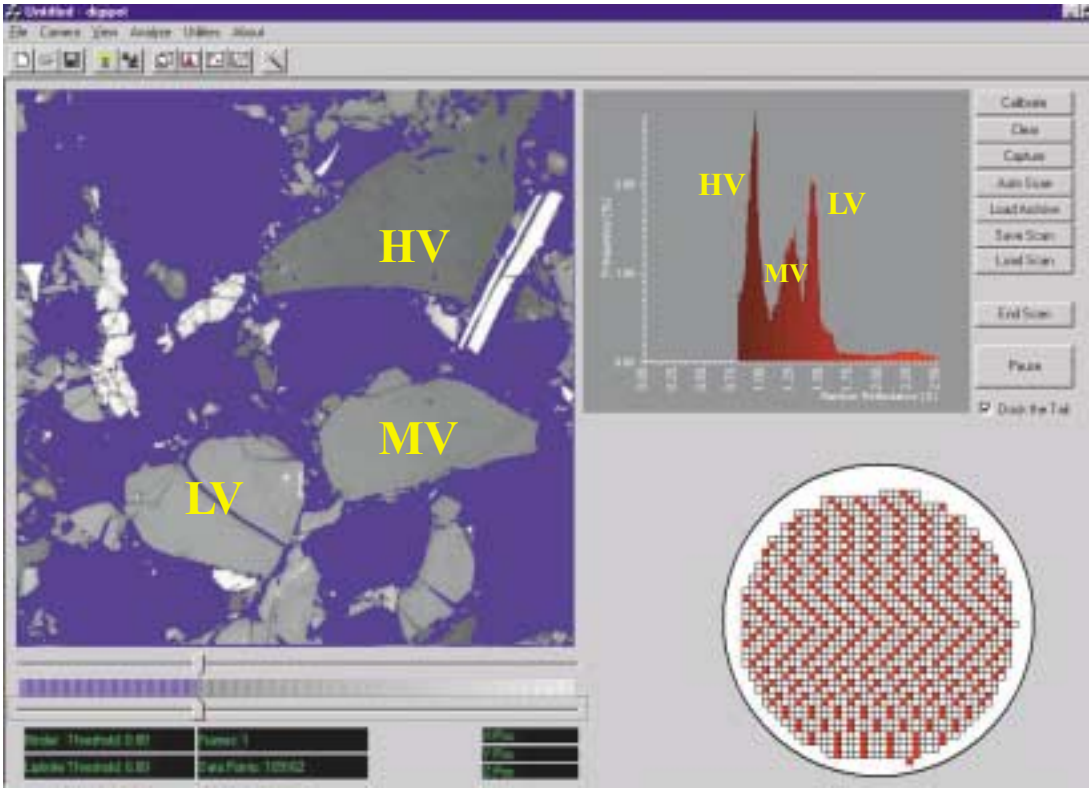
Fingerprinting coals is a new petrographic technique that uniquely identifies and characterizes a coal sample. This brochure describes its application to coking coals.

Digipet® is the most advanced machine-vision robotic-system designed specifically to analyse coking coals petrographically. It comprises an extremely sensitive digital camera, which is calibrated to record the range of coal reflectance, and a precision positioning stage to move the sample. Reflectance measurements are collected from over 84.7 million locations on the surface of a prepared pellet, and those of mineral matter and pellet binder are discarded. The remainder, being reflectance values only of coal, are displayed in the form of a histogram - the Reflectance Profile, or *Fingerprint*, - that is unique to the coal sample. By comparing Reflectance Profiles, a rapid assessment can be made of the similarity, or difference between two apparently identical coals, like those in adjacent barges.

This technology has been used to monitor blends at the non-recovery coke ovens of the Indiana Harbor Coke Company since 1998. Samples taken when charging the ovens, are analysed within hours, and if *Fingerprinting* confirms the blending target has been met, then quenched coke is routed directly to the world's second largest blast furnace - Ispat's Number 7, shown below. *Fingerprinting* is therefore the last test of the coal prior to feeding the furnace with coke.

In the foreground are IHCC's non-recovery coke oven batteries at Indiana Harbor, East Chicago. Dwarfing them in the background is Ispat Inland's Number 7 blast furnace.

What's a fingerprint?

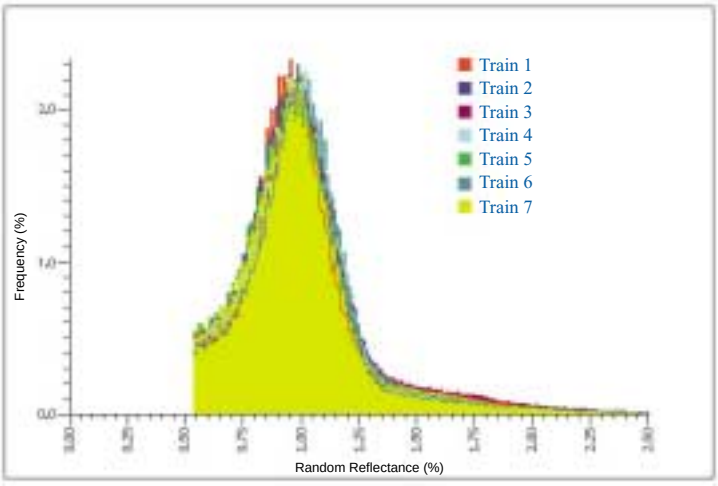


Digipet's data-collection window, shown above, comprises three elements; an image of coal, a Reflectance Profile, and a map of image-sampling sites on a pellet. Areas in the image with low reflectance are binder, and are coloured blue. The gray and white grains are coal, including Vitrinites from three different ranks of coking coal. These are labelled High-vol (HV), Med-vol (MV), and Low-Vol (LV) respectively. The Reflectance Profile of this image is shown at top right, and contains three distinct peaks - each corresponding to the volume occupied by the different ranks of coal. An image consists of 262,000 pixels, which is reduced by the discarded binder, so that only 110,000 coal reflectance values comprise this Reflectance Profile. On each pellet, 339 such images are captured from the red sample sites shown on the map. The resulting Reflectance Profile is the most detailed spectrum of the coal's character that can be measured by today's technology, and can be considered a state-of-the-art *Fingerprint.*

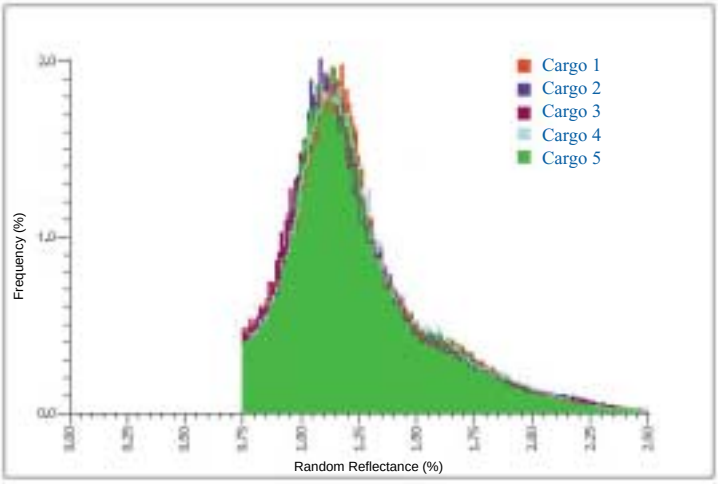
Reflectance Profiling is ideal in the following situations.

1. Visually confirm quality of coal shipments.
2. Determine the Rank and potential Coke Strength of a coal.
3. Determine proportions of coals in blends.
4. Derive the Coke Strength of blends.

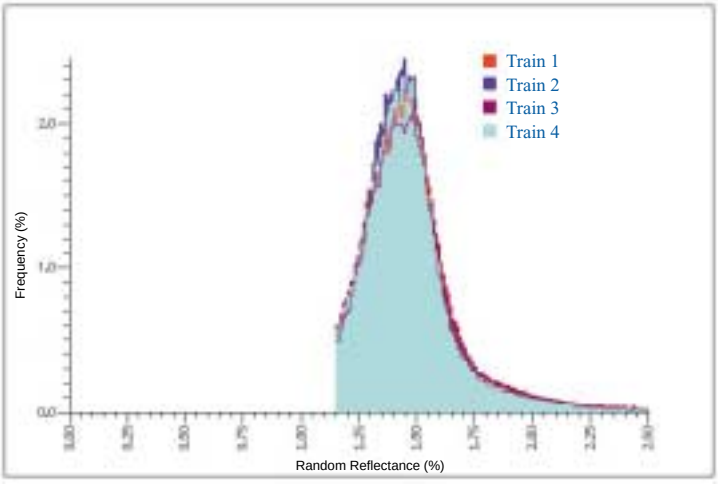
The Uniqueness of Fingerprints



Appalachian HiVol from West Virginia.



Canadian MedVol from British Columbia.



Appalachian LowVol from WestVirginia.

Although coking coals from the Appalachian coalfield and from Western Canada are superficially similar, they are different in many characteristics, (age, rank, maceral composition, type of ash, etc.), including the uniqueness of their Reflectance Profiles, or *Fingerprints.*

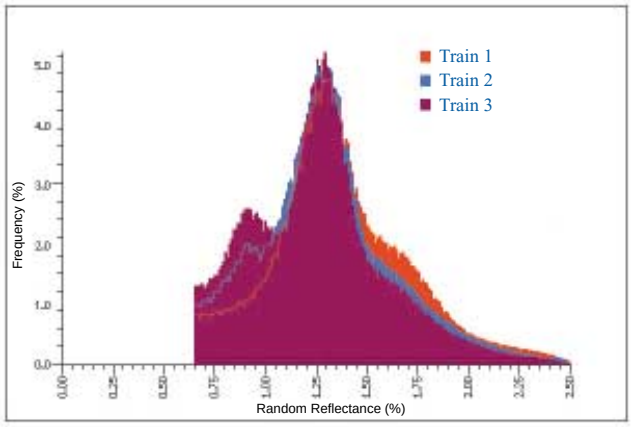
To obtain coke of the highest quality, coals with desirable qualities of different provenance are mixed together in blends.

Several Reflectance Profiles of each of the three ASTM rank categories of coking coals which participate in this blending, are shown here to demonstrate the ability of the Digipet system to produce time-after-time *Fingerprints* of identical cargoes.

Notice how the position of the *Fingerprint* peak moves to higher reflectances during the progression from HiVol (yellow at top left), through MidVol (green at middle left), to LowVol (blue at lower left).

Monitor Cargo Consistency by Fingerprints

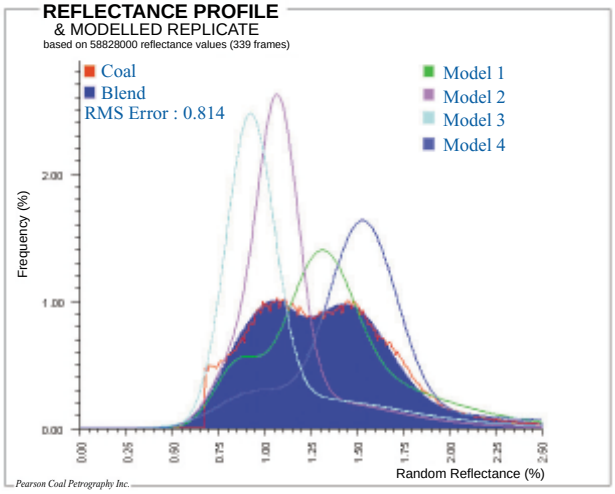
Because reflectance profiles are unique, they can be used to identify in successive cargoes any changes which may be present, whether caused by geological change and substitution (rank and type), or contamination. Reflectance Profiling is therefore a rapid screening techinque to identify consistency or change. Numerous examples of consistency are shown on the opposite page, where identical profiles are stacked, one on the other. A glaring example of inconsistency among cargoes is shown on the right, where the *Fingerprints* of three train cargoes should all be the same, with one peak!

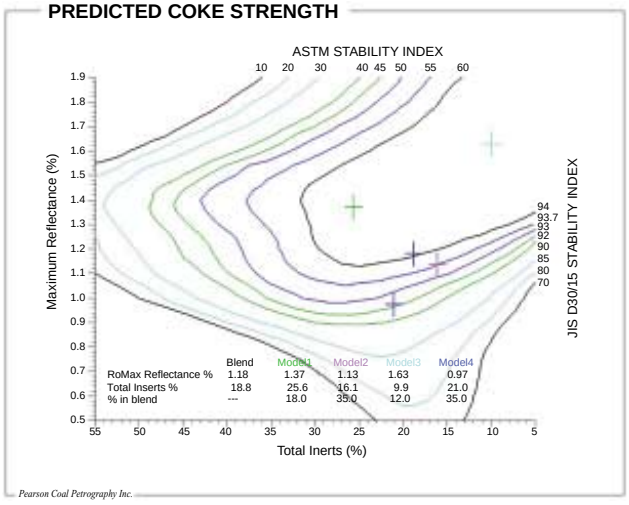


Interpretation of a Blend Fingerprint

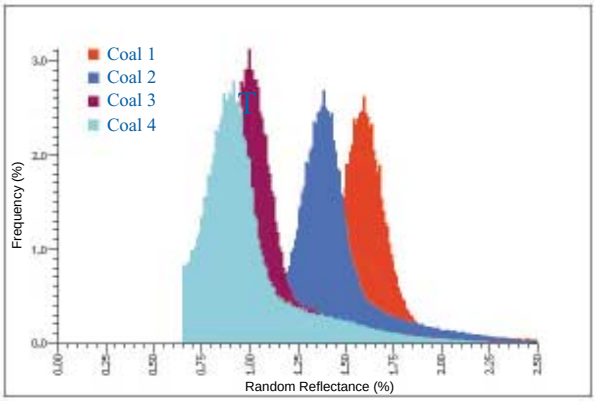
To determine manually the petrographic proportions of coals in a blend, is time-consuming, and an almost impossible task - unless you use automated *Fingerprinting*!

To interpret the proportions of components in a blend (upper right), numerical models of the components are assembled together with the *Fingerprint* of the blend sample to be deconstructed (shown in red). The models are listed at top right. Replication of the blend profile by iterative manipulation is performed until the smallest root-mean-square error is obtained, giving, as close as possible, the modelled replicate. This modelled profile is shown in blue. The blue and red profiles are therefore very similar. From this modelled best-fit solution, the composition of the blend sample is inferred. A vector plot shows the predicted coke strength from the proportions of the individual components in the blend (lower right).

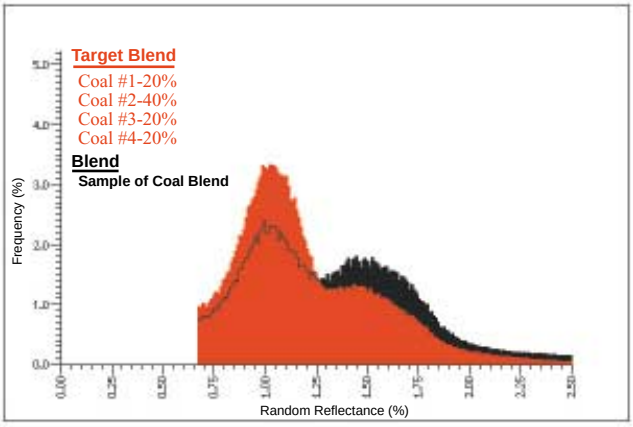




Designing a Target Blend using Fingerprints



Reflectance Profiles of component coals to be used in making a blend are assembled and the computer mixes them together in the proportions of the desired recipe. This preliminary stage is shown above.



The Reflectance Profile of the computer-built target blend is displayed with the proportions of the components listed. This virtual coal blend can then be compared to a real sample of the blend, as shown above.

Protection for conventional Slot Ovens

Low volatile bituminous coal from the Appalachians makes very strong, dense coke. However, during carbonization in conventional slot-ovens, as it is transformed to coke, this type of coal exerts considerable pressures on coke oven walls. To reduce this potentially catastrophic coking pressure, coals of lower rank are blended with the low volatile coals. Unless the content of the low volatile coal is carefully controlled and measured, damage to brick oven walls will result, with increased maintenance costs, and lost production time with “stickers”.

Fingerprinting blends to determine their low volatile coal contents may be a cost-effective way of protecting an older battery, and reducing problems associated with coking pressure.

Conventional Petrography

Fingerprinting augments conventional coal petrography in situations where the results of a full petrographic analysis of a sample, (Vitrinite Reflectance analysis and Maceral Analysis to ASTM or ISO Standards) are still not accurate enough. The rapid determination of blend composition being one obvious example. The visual comparison of *Fingerprints* of cargoes delivered to a port or a client provides another. In this instance, *Fingerprinting* could reveal that a sample delivered to a terminal and loaded on a vessel has the same *Fingerprint* and is in the same condition as shipped from the mine. Considering the costs involved in determining where a contaminant coal was introduced to a once pristine cargo, *Fingerprinting* may provide inexpensive insurance.

Productivity & Sample Turn-around

Some of our contracts require reporting of proportions of component coals in several samples of coal blends within four hours of their receipt at the lab, and to achieve this level of productivity we have employed several innovative sample preparation techniques at all of our labs. For example, to ensure that the ratio of coal to binder is always identical in our petrographic pellets, we use powdered lucite as the binder, replacing the epoxy resin favored by others. The pellets are formed and cured in automated pellet making machines equipped with duplex mold assemblies. A pelletizer produces two ready-to-polish pellets in twenty minutes.

Automated polishing equipment is used to polish six or ten pellets for microscopic examination, in twenty minutes.

When received in dry condition, most samples receive same-day service, which means results are posted to the Internet in less than 24 hours.

Pearson Coal Petrography, Inc.

Since 1981, we have grown to become North America's largest coal petrographic services company, now with four strategically located laboratories. We invented coal *Fingerprinting*, and results of all our analyses are available to clients over the Internet, via our secure servers . We continue to innovate as we strive to serve you better. Visit us online, and see for yourself.

http://www.coalpetrography.com

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