SUITABLE AND SAFE SAMPLING

Collecting coal samples can be accomplished in a variety of ways – some less than ideal. **Paul Reagan, Sampling Associates International, USA,** examines the relative effectiveness of the various methods and the specific limitations of coal sampling, as well as introducing a new sampling device that may be useful in certain situations.

In many commercial coal sales transactions, the contractual language addressing the sampling method simply states that the samples will be taken "in accordance with ASTM (or ISO) standards", without any additional specificity. It is one objective of this article to inform the reader that this is a mistake: understanding the effectiveness of the various sample collection methods is crucial to clarifying what method is to be used in the

contract language. Both ASTM and ISO have a number of different sampling methods and, without specifying, either party can select an inferior method and still be in compliance.

ASTM and ISO have standards addressing both mechanical and manual sampling of coal. Mechanical sampling is addressed by ISO 13909 and ASTM D 7430. Manual sampling is addressed by ISO 18283 and several different standards in ASTM. One is manual sampling using part-stream sampling (D 6609); the other is stationary sampling in railcars, barges or stockpiles (D 6883). Thus, any of the manual methods in these standards could be used and still be "in accordance with ASTM (or ISO) standards".

Ranking the sampling methods

Below are the details and ranking of these various sample collection methods, which will allow the user to better select the method they actually require for their transaction.

In ASTM Standard D 2234, the standard practice for the collection of a gross sample of coal, the sampling methods are ranked from best to worst in accordance with their condition. ISO standards are in close agreement with this. They are as follows:

- Condition A: stopped-belt cut sampling.
- Condition B: full-stream cut sampling.
- Condition C: part-stream cut sampling.
- Condition D: stationary sampling.

The key to understanding why condition A is the best method and condition D is the worst method is that many of the coal characteristics that are commercially relevant (moisture, ash, calorific value, etc.) are not distributed equally in the different size fractions in the consignment.

A simple, but important, example of this is shown in Figure 1. This shows a sample from a barge of coal from a single mine, which is first screened into its various size fragments and then analysed for dry ash. The resulting distribution of ash in the different size fractions is very typical, with lower ash in the larger pieces and higher ash in the smaller pieces. Many coals have wider ranges compared to the example here. Ash content and calorific content are inversely proportional; as the ash rises the calories fall.

Moisture content is directly related to surface area, therefore the same effect is seen in percent moisture with the fine coal having much higher

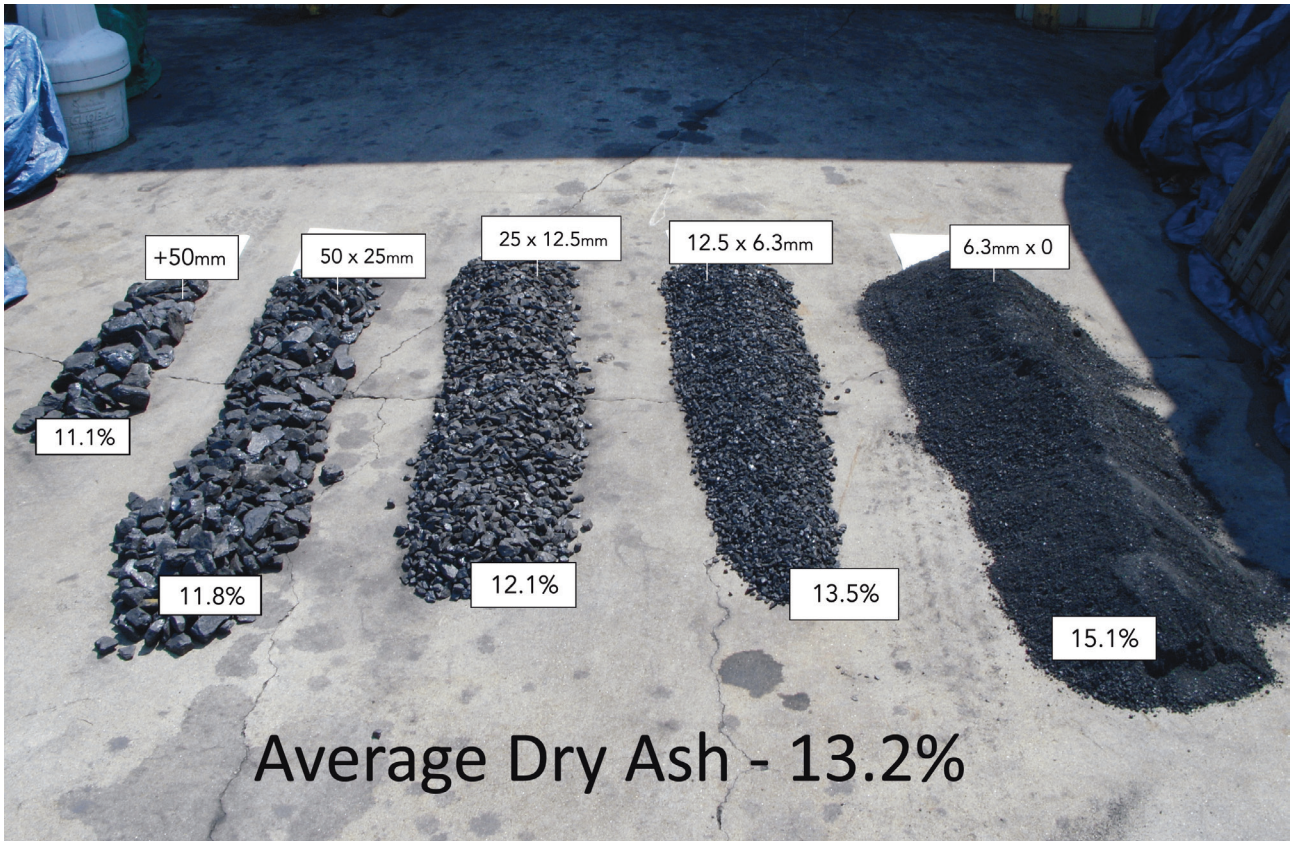

Figure 1. The ash content changes with different sized particles.

moisture content than the larger pieces. These two distributions of high ash and high moisture in the fines have a compounding effect on one of the most important commercial issues: as-received calorific value.

Due to this disproportional distribution of important characteristics in the different size fractions (true for most bulk materials), the true objective of any sampling method is to capture the same size distribution in the consignment in the gross sample (before any crushing or dividing). Failure to do so will produce a test result that is biased towards the characteristics in the size fragment that is over represented.

The preceding four sampling conditions are ranked from best to worst on their effectiveness in accurately capturing – in the sample – the size distribution of the cargo.

Probability versus judgment sampling

The other key to understanding this ranking is that cargos of coal segregate by particle size whenever they are handled. It is common to see particle size segregation when coal is being stacked into a stockpile with the large pieces rolling down the sides to the base. However, there is quite a bit of segregation that is not as visible to the human eye, which takes place while coal is on a conveyor belt rolling over idlers or passing through transfer points.

In order to ensure that the sample collection method can accurately capture the particle size distribution in the consignment, one fundamental rule must be met: all parts of the fuel (coal) in the lot shall be accessible to the sampling instrument and parts of equal mass shall have an equal probability of being selected and included in the sample.

This fundamental requirement has two parts. The first part is that since all of the fuel (coal) in the lot shall be accessible to the sampling instrument, the sampling must take place as the cargo is moved from one location to another. The second part is that since all the particles of equal mass must have an equal chance of being selected for the sample, the sampling method must have the ability to overcome the natural size segregation that occurs when coal is handled.

Those sampling methods that meet these requirements are called probability samples. Those that do not are called judgment samples.

In effect, condition A (stopped-belt sampling) and condition B (full-stream sampling) satisfy these two requirements and are thus probability samples. They both take place as the consignment is moved by conveyor belt so every particle in the consignment is accessible to the sampling instrument and has a chance to be selected for the sample. In addition, they both have the ability to overcome the natural size segregation that occurs when the coal is handled because they both take a full-stream increment, which means they capture the correct particle size distribution even when it is segregated.

In condition C (part-stream sampling) and condition D (stationary sampling), neither of these two requirements can be met. In both of these sampling methods, large parts of the consignment have absolutely no chance of being selected for the sample. And neither method is able to overcome any segregation that does occur because that can only be done with a full-stream cut. As such, both of these methods are judgment samples.

The reason that condition C is ranked higher than condition D is that condition C takes place when the coal is being moved on a conveyor. This means that much more of the consignment is accessible to the

Figure 2. Installation of a Mechanical Part-steam Sampler (MPS).

Figure 3. The MPS includes double sample scoops (Note: during operation, they alternate via a timer).

Table 1. Comparison on blended coal – dry basis results						
Method	Moisture	Volatile	Ash	Sulfur	BTU	Calories
Mech.	7.62	35.17	14.21	0.87	12 688	7049
MPS	7.12	35.27	14.50	0.84	12 652	7029
Method	Moisture	Volatile	Ash	Sulfur	BTU	Calories
Mech.	7.68	34.23	14.08	0.85	12 663	7035
MPS	8.14	34.89	14.19	0.85	12 639	7022
Method	Moisture	Volatile	Ash	Sulfur	BTU	Calories
Mech.	7.52	33.30	15.11	0.86	12 631	7017
MPS	7.78	33.91	14.61	0.87	12 688	7049

Table 2. Comparison on petroleum coke – dry basis results						
Method	Moisture	Volatile	Ash	Sulfur	BTU	Calories
Mech.	7.53	10.72	0.51	5.59	15 242	8468
MPS	7.91	10.52	0.47	5.60	15 276	8487
Method	Moisture	Volatile	Ash	Sulfur	BTU	Calories
Mech.	7.14	10.66	0.50	5.30	15 268	8482
MPS	7.46	10.71	0.49	5.33	15 311	8506
Method	Moisture	Volatile	Ash	Sulfur	BTU	Calories
Mech.	7.97	10.75	0.54	5.66	15 189	8438
MPS	8.01	10.74	0.54	5.63	15 229	8461

sampling instrument; therefore the chance of that sample being representative is higher.

ASTM has one standard for stationary sampling, which covers the sampling of barges, railcars (wagons) and stockpiles. The sampling of railcars is preferred to barges, and barges preferred to stockpiles. The commonsense reason for this is that a larger proportion of the consignment is accessible to the sampling instrument (because the tonnage in railcars is smaller than in barges, which, in turn, are usually smaller than stockpiles).

However, it is important to remember that it is not just the size distribution that is important, but also the moisture distribution. Moisture in stationary coal almost always migrates to the bottom of the stockpile, barge or railcar. In addition, there are frequent moisture changes right at the top surface layer (drying or precipitation). Stationary sampling cannot usually reach much past the surface of consignment and so it is very difficult for even the most experienced and diligent sampler to overcome these challenges.

One important comment on judgment sampling is that, in most cases, the samples are collected manually, which introduces another risk element. Both ASTM and ISO standards recognise the human element in sampling and ranks those methods without the human element higher than those with. There are many excellent manual sampling technicians, but ultimately they are exercising their judgment on which particles from the consignment get into the sample.

Theory versus reality

The discussion above lays out the reason why most of the modern coal trade is governed by samples collected by full-stream mechanical sampling systems. Even though condition A (stopped-belt sampling) is the theoretically most desirable method, it is not practical in large-scale coal commerce since the conveying equipment simply cannot be stopped and started, under load, multiple times an hour. As such, stopped-belt sampling is only implemented as a reference sample during certification tests (bias tests) or in special circumstances. As such condition B (full-stream sampling) is the better and most practical way to ensure the capturing of the size and moisture distribution of the cargo into the laboratory samples.

The probability samples of condition C and D have their place in the commercial world because full-stream mechanical sampling is not always available – or financially justifiable. But it is important for counterparties in a transaction to understand the limitations and risks of probability sampling and understand how to reflect that in their commercial agreements.

Mechanical part-stream sampling

One example of the need for condition C (part-stream sampling) occurs when the mechanical sampling system in a terminal breaks down or is damaged by debris entering the system. In these cases, it is necessary to balance the time it would take to make the repair versus the cost of stopping the loading.

At most export terminals, a limited amount of time is allowed to make repairs, but there is a manual sampling protocol in place so that loading the ship or barge can continue. This is usually a part-stream sample collected manually with a shovel from a moving conveyor belt. In almost all cases, it is temporary and only small portions of the overall cargo is collected this way.

The ASTM Standard for this type of sampling is D 6609. Even though it is a judgment sample, it is still important to have rules and use common sense to overcome, as much as possible, the inherent challenges in this type of sampling. For example, it is good practice, especially on larger conveyors, to use two personnel so that both sides of the conveyor can be reached by the sampling instruments in order to account for the segregation of material – especially in blends – on either side of the conveyor.

One issue that has emerged in the mechanical sampling world is that many terminals, in their pursuit of economies of scale, are operating at higher and higher flow rates. To accomplish this, the conveyor belts are larger and operate at much higher speeds. In some cases, it is simply no longer safe for the back-up part-stream sampling from the conveyor to be performed manually. In these ports, there is no back-up method other than stopping the loading or sampling at the stockpile – which reverts to using the lowest ranked sampling method and which places a sample technician in a position of danger.

To provide an alternative, Sampling Associates, in cooperation with a mechanical sampling system manufacturer, has developed a sampling device: a Mechanical Part-stream Sampler (MPS: see Figure 2; p. 32). The MPS, which has a patent pending, is still a condition C method; it does not replace condition B sampling. However, because it is fully mechanised and removes the human element, it is a significant improvement on manual part-stream sampling in two important ways.

The first way is that it is much safer. No person is exposed to the moving conveyor parts or harsh weather. Secondly, it removes the human element in the timing of the sample increments and the selection of material into the sample. An additional benefit of using the MPS is that it frees the technician to concentrate on getting the mechanical sampler back online, instead of manually sampling and calling in other personnel. Its main features include:

- All stainless steel construction for long-term prevention of corrosion.
- Two alternating sample scoops to reach both sides of the conveyor (Figure 3).
- The scoops are designed to reach deeper than a person with a shovel can.
- The scoops operate in the same direction of the material flow.
- The frequency of sampling is programmable, based on the lot size and flow rate calculations.
- A small footprint on the conveyor belts.

A number of North American coal export terminals have already installed an MPS or have orders in the pipeline. Table 1 and 2 show data collected at two different terminals (one for coal: Table 1; and one for petcoke: Table 2) comparing the MPS to a sample collected by a mechanical sampling system.

The data is encouraging, indicating that this device is a safe alternative to full-stream mechanical sampling. Even though this device was developed solely as a backup to mechanical sampling at high-volume high-capacity export terminals, its performance has attracted the attention of smaller terminals and petcoke refineries where either cost constraints, or the consistency of the material, allow for the MPS to become a primary sampling option.

Conclusion

In summary, knowing about sampling methods and their limitations is important to both sides in any commercial coal transaction. The probability samples collected by full-stream mechanical sampling will always be paramount. But it is also important to know the judgment sampling alternatives. The development of the MPS introduces an important new alternative method available to the coal industry. WC

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