Sampling considerations

Paul Reagan and Joe DeMatteo, Sampling Associates, US, outline considerations for the selection and installation of mechanical sampling equipment.

All sampling standards recognise that the best time to collect a sample is when the material is being moved from one location to another via conveyor belt. This provides the best chance for all particles in the consignment to be selected for inclusion in the sample.

The sampling standards also agree that the best way to collect sample increments is by stopping the moving conveyor under load and taking full cross-sections by collecting all the material (lumps and fines) between two parallel planes (see Figure 2). This is the best way to ensure that the fundamental objective is achieved - that the size distribution in the sample is the same as the size distribution in the consignment.

As the number of individual increments required to make up a full sample is large, the 'stopped belt' sampling method is not practical for day-to-day operations. The frequent stopping of the conveyor belts under load is too disruptive to normal operations and causes stress to the conveyor drive motors. As such, the next best type of sampling is to collect the full cross-section increments from the coal without stopping the conveyors. This is where mechanical sampling comes in.

Cross-stream or cross-belt?

Sampling systems consist of mechanical components to collect and composite together a series of initial, or primary, increments - then process those increments into a smaller mass (for transport to the laboratory) while preserving the integrity of the sample at each step.

There are two different methods to collect this primary increment. One is by collecting a cross-section from a falling coal

stream at a transfer point between two conveyors. This method is known as cross-stream sampling. The second method is by collecting the primary increment by sweeping a cross- section of the material from a conveyor belt. This is known as cross-belt sampling (see Figure 2).

Figure 1. Cross-belt primary sampler on empty conveyor.

Figure 2. Stopped belt sampling.

Cross-belt samplers have some competitive advantages. The first is that cross-belt samplers collect a much smaller mass of primary increment than do cross-stream samplers. Even though the width of the primary cutter opening on both designs is the same, the speed of the cross-stream sampler must be kept below the point where it selectively rejects larger particles.

Cross-belt samplers, on the other hand, can be very rapid as they 'sweep' through the coal on the conveyor belt - in fact, the faster the better. This rapid transit time results in less sample mass collected (many times less than cross-stream samplers). This difference in primary increment mass translates into a significantly lower scale on the 'downstream' material handling and processing components. Consequently, cross-belt systems have a significant price advantage.

The second advantage of cross-belt samplers is their ease of installation. Most are installed directly onto the conveyor structures (see Figure 3) and therefore do not require any extra engineering to install their primary samplers in the chute work at a transfer point. This is another price advantage and also means that cross-belts sampling systems can more easily be retrofitted to existing conveyor belts.

Figure 3. Primary sampler installation onto existing conveyor.

Due to the above factors, the vast majority of the mechanical sampling systems installed today are of the cross-belt design. As a result, the remainder of this article will focus solely on the cross-belt sampling systems.

Overview of equipment design considerations

When selecting the design and layout of a mechanical sampling system it is important to understand that there are a variety of ways to accomplish the objective of sampling. While it is the goal of this article to provide a survey of the factors that should be taken into consideration, there is no substitute for doing your own research to clearly spell out what you want from the manufacturers in your Request for Quotation (RFQ).

Consider the analogy of buying an automobile. If you issued a simple RFQ stating only that you wanted a vehicle to get you from point A to point B, you might get some very attractive prices, but you might not be pleased with your choice once you started to drive it. While price is always an important consideration, there are many others. It is therefore a mistake to assume that all manufacturers and designs are equivalent. The adage of 'you only get what you pay for' can be extended to include 'you only get what you ask for' when it comes to sampling systems.

Unlike an automobile, it is not easy to trade in a sampling system. Once purchased and installed, it can be difficult and expensive to correct major problems. And some problems will not show until after many hours of operation. Your RFQ should include as much detail as possible. Below you will find the issues to consider in designing yours.

Do your homework

We strongly recommend that your research includes the inspection of existing sampling systems at applications that will be closely similar to yours. Speak to the owners about their experiences and items to include and problems to avoid, with particular attention to after purchase solutions that were required.

Know the products that your system will sample. Be sure to think through the range of qualities (i.e. HGI and moisture content) and consignment sizes the system will face. This is especially important at terminals with multiple users and frequent blending. This will greatly assist the manufacturer to design a better system for you.

Buyers are frequently disappointed by the amount of human attention mechanical sampling systems require in order to function properly. Thoughtful selection of hardware and features will help to minimise the amount of future effort required.

Location

Selecting the location for your sampling system is an important first step. The system should be located as far 'downstream' as possible in the sequence of conveyor belts so that all possible blending scenarios take place prior to reaching the sampling system.

A second consideration is access to the conveyor belt. The 'ideal' location is always a balance of the availability of space on the conveyor for the primary sampler and space on the ground to locate the processing equipment. Most modern sampling systems have very small footprints and are housed in standard cargo containers. Purchase a large cargo container and add heating and air conditioning for the operators to have a small office and spare parts storage. Access to the area by vehicle is very important. Availability of the appropriate electrical service can be an issue.

The location of the primary sampler on the main conveyor can be a cost issue as well as a quality issue. If the primary sampler is located at a high elevation, then the length of the conveying system will be longer (and therefore more expensive) for both the sample material and the unused sample returned to the conveyor. In addition, it is not good sampling practice to allow sample increments to drop from extreme heights as it can cause drying of the sample as it falls and breakage of the larger particles upon impact.

If there is a conveyor scale on the main conveyor system, the vibration from the primary sampler can affect its performance. Locate the primary sampler on a different belt, if feasible. If not, locate it as far as possible from the scale (and no less than

20 ft). Finally, keep an eye out for housekeeping issues. Locating a sampler near dust suppression systems or conveyor belt wipers will cause a cleaning nightmare and either compromise the sample or shorten the effective life of the equipment through corrosion.

Attention to detail

Attention to detail always pays off. You should conduct a review of the local building and operating codes. Some codes require explosion-proof components and some do not. Different codes will involve different design and costs.

Being specific in your RFQ not only gets you what you need but will make it easier to compare the quotations from different manufacturers. The manufacturers are trying to provide you with the lowest price. If your RFQ lacks specificity, you are more likely to get the compromises that the absolutely lowest priced system inevitably requires.

If you do not ask for it, you will not get it. One prime example is the size of the crusher. Crushers are an expensive component and occasionally the smallest possible is quoted in order to reduce cost. Effective crusher capacity can be reduced by many factors (i.e. moisture content) and selecting the right crusher is important

Figure 4. Adjusting the primary sampler belt wiper.

Figure 5. Stainless crusher feed chute with inspection door, vibrator and local motor lock out panel.

Figure 6. Compact modern cross-belt mechanical sampling system.

to avoiding this potential 'Achilles heel'. To avoid frequent plugging, it is usually preferable to run more material through a larger, higher capacity, crusher than to move less material through a smaller crusher at the higher range of its capacity.

Smaller examples of cost saving measures are using flexible conduit in lieu of rigid conduit and screw conveyors instead of conveyor belts. Screw conveyors can be cost-effective but wear more quickly and can cause maintenance problems in cold weather.

The sampling system manufacturers can be an invaluable source of information on these and other issues with sampling systems. The manufacturers should be very happy to educate you on the many sampling system issues and we find that extensive discussions with the various vendors reveal which are the better ones.

Ease of maintenance

Maintenance is critical to sampling system performance and the design should maximise the ease of access to components for preventive maintenance and repair. While there is a legitimate concern that easy access can cause safety risks if not well designed, components that are difficult to access will not get the attention they need. It is vitally important that the design contains adequate inspection and maintenance doors for each individual component and vulnerable plugging points.

One valuable feature that enhances both safety and access is having electrical disconnects at each component. Unless otherwise specified, there will usually be only one place to safely lock out the equipment - at the electrical panel. By placing a lockable disconnect locally at each component, the operators can quickly and effectively make the component safe to clean and inspect.

Another valuable feature is an 'easy access' crusher, which thankfully is becoming the industry norm. Crushers are high wear items that are quite prone to plugging. Selecting the crusher with the best access will pay off many times over in reducing downtime and ease of the replacement of crusher hammers and screens.

One very important example of maintenance access is adequate decking and access to the primary sampler. We have seen many systems installed that did not supply any access to the primary sampler because it was not asked for in the RFQ. As a result these primary samplers are never inspected or adjusted. On cross-belt samplers there is a critical wear component on the edge of the primary sampler that wipes the conveyor belt clean of fine particle sizes which needs regular adjustment (see Figure 4).

Think about the long run

Sampling coal and coke is a rigorous application. Both products can be very abrasive and corrosive and the movement of this material through metal chutes and sampling devices inevitably takes its toll on the equipment. Cutting costs through less robust metals and materials will always reveal themselves as the equipment operating hours mount.

Thickness and grade selection of steel is important. Stainless steel is essential in high wear areas or places where coal will stick and start to corrode mild steel. Be sure that the angles of all chute work are steep, have smooth surfaces and rounded corners to prevent coal accumulation. High density plastic wear plates at key locations can be very helpful.

Often overlooked are such issues as primer coats and paint type - where poor materials and application will reveal themselves as the years go by.

Ensure that the conveyor structure on which the primary sampler is mounted is as robust as possible as constant imperceptible flexing can cause metal fatigue through multiple repeated cycles. One recent innovation is the use of a hydraulic clutch and brake combined with a constantly running motor instead of a motor that only operates periodically.

Maximise your flexibility

Another important area where advance planning can pay off is designing your mechanical sampling system with operational flexibility in mind. Whenever possible allow for changes in the size and make up of consignments that are sampled. Anticipate potential plans for expansion and productivity enhancement such as a future increase in the speed of the conveyor belt from which the samples are collected.

Variable speed drives on sampling system feed conveyors should be part of the design. Variable speed drives provide the capability to handle many different sampling situations by controlling the rate of flow of material through the sampling system components as it fluctuates with the number and frequency of primary increments.

A key tool in maximising operational flexibility is to take advantage of the capabilities of the Programmable Logic Controller (PLC). First of all, be sure to have the software to modify the program included in your purchase. This will allow for changes in the case of unanticipated operational requirements or the addition of new equipment in the future. Be sure to allow for the expansion of the PLC to gain more inputs and outputs. Whenever possible, set up the sampling system to receive inputs on flow rate and tonnes loaded directly from a conveyor scale.

Be sure your system is installed and equipped with appropriate feedback loops, detection devices and electronic information components. Vibrators and plugged chute indicators should be installed at strategic locations on chutes throughout a sampling system. Vibrators will help reduce system plugging when sampling wet or fine coal (see Figure 5).

Primary samplers must always have a relay interlock with the main conveyor to shut it down to prevent damage and excessive coal spillage if the primary sampler should fail whilst still in the coal stream. In addition, primary sampler activation should always be interconnected with the scale or a 'material on conveyor' signal to prevent unnecessary activation of the primary sampler if no material flow is present.

Take steps through the use of magnets and electronic metal detection to prevent damage to the sampling system from the introduction of metal objects.

Fabrication and installation

Once all of the customised design specifications have been finalised and a vendor selected, it usually takes somewhere between 12 and 16 weeks for fabrication. This time is highly variable depending upon the order book of the chosen manufacturer so it is wise to allow for plenty of time. Understandably, the best manufacturers are often the busiest.

Be sure to scrutinise the approval drawings and blueprints for compliance with the purchase agreement. It is always a good idea to appoint a project co-ordinator to track the fabrication and execute frequent inspections at the manufacturer's facilities. Witness the make-up and assembly of major components and their drive units. Confirm the cutter openings at the shop and ensure that fasteners are rigid and adequate. Be certain that there are no cracks or crevices that could affect sample integrity or trap coal and start premature corrosion.

Many of the components are assembled at the shop and transported as a unit. Inspect the components closely when they arrive for damage during transport.

Many manufacturers will also quote the installation as part of their bid. We recommend this when possible (assuming it is economic) as they will have the most experienced field personnel. Be prepared to closely supervise the installation. Shortcuts may sometimes be taken if representatives of the buyers are not onsite - particularly if an inexperienced contractor is used. Closely monitor field installation of items such as belt splices and the tolerances of cutter placement on the conveyors.

For those that do not have much experience purchasing and installing sampling equipment, hiring an independent third party expert to be your supervisor and advocate can prevent many problems from happening.

It is very common for unforeseen events and unexpected challenges to occur during installation and startup. This is when the selection of a reputable manufacturer will pay dividends.

Calibration and certification

The installation is not complete until the sampling system has been calibrated and certified. Calibration starts with setting the operating parameters such as cutter frequencies, cutter speeds and conveyor speeds. These parameters then need to be tested using coal under expected operating conditions. As long as the sampling standard minimums are met, there is latitude to set the operating parameters to achieve a good flow of material through the sampling system. It is important to achieve a balance between enough flow to prevent moisture loss from the sample (especially in the crusher) and enough unused capacity for the sampling system to handle the highest peak flow rates on the main conveyor.

For each set of sampling parameters (such as for different lot sizes), the sampling system is designed to produce a set mass of sample per 1000 t sampled (known as the sampling ratio). The first measure of proper operation is that the actual observed sampling ratio mass is within 10% of the design ratio.

The sampling ratio should then be assessed using Statistical Process Control (SPC) to determine whether the sampling process is under control. Once control is achieved, including a coefficient of variation of less than 15%, the sampling system can be considered to be calibrated and is ready for the certification test - known as a bias test.

The bias test is a controlled test whereby a series of samples (usually around 30) is compared to a similar series of reference samples to confirm that there is close statistical agreement. The method for collecting the reference samples for the bias test is none other than the 'stopped belt' samples generally accepted as the best sampling method possible. In short, the bias test confirms that the best practical sampling method (mechanical sampling) is comparable to the best possible sampling method (stopped belt sampling) and that there is no bias between the two (Figure 6).

Conclusion

Purchasers of sampling systems should do their homework and not only understand the variety of options available but be able to clearly communicate their needs in the RFQ. Advance planning and oversight throughout the process are important to a successful installation.

In most cases the sampling system will be used to produce samples used to make critical operational decisions and/or commercial payment. We find it useful to think of procuring a mechanical sampling system as purchasing a 'cash register' to track your money. Be sure to get a good one from a manufacturer with a proven track record and a reputation for standing by their product.