INSPECTION AND SAMPLING

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The value of a bulk cargo is often determined from testing a sample collected by a mechanical sampling system (MSS). Should the MSS be biased or inconsistent, the value of the cargo can be inaccurately or imprecisely determined, the cargo can be over- or under-valued, and the buyer or seller can be erroneously compensated for the value of the cargo. Expensive, wrong decisions can be made based on incorrect or erratic data. The value of a mineral cargo being loaded onto a barge is determined from a sample, often collected by a mechanical sampling system.

Mechanical sampling systems (MSSs) are use to sample bulk solids

Manual gross increment collection.

Manual reduction/crushing.

Mechanical sampling systems (MSSs) are use to sample bulk solids being received from the mine, processed through the plant, produced by the plant, loaded into a vessel, or being discharged from a vessel.

RISK MINIMIZATION

To minimize the risk of improperly determining the value of a cargo, MSSs are designed for the specific characteristics of the material to be sampled, are installed and maintained by competent personnel, and are shown to be capable of performing as intended through performance/bias testing and ongoing quality assurance programs.

MSS DESIGN SPECIFICATIONS

A MSS collects and processes samples from high tonnage conveying systems where it would be very difficult or dangerous to obtain samples manually.

There is an obvious material component of MSS design and performance. Different materials, with various shapes, densities and sizes, will interact with the MSS in different ways and can have different extraction ratios. A MSS designed to operate at one set of conditions (material type, topsize tons per hour of feed, and so forth) may not collect an accurate sample at another set of conditions.

Manual division.

It is impossible to design an effective MSS without detailed information about the location of the MSS and the material to be sampled (including its topsize, surface moisture content, and hardness or friability). A site visit is often required. This article cannot cover all aspects of MSS design for a specific system, but the MSS design shout meet the following general requirements:

- the requirements of the pertinent international standard, e.g. ASTM International or ISO, must be met;
- opening widths (or heights) of cutters, conveyors, and chutes must be at least 2.5 times the topsize of the material
- chute work must have angles that are greater than the angle of repose of the material;
- there must be no choke points in conveyors and chutes
- the MSS must be as compact as possible;
- the MSS must be as airtight as possible;
- the MSS must have access doors, which can be used to observe the system's operation, e.g. allowing verification that the cutters are correctly sized and shaped, are moving at the correct speed, and are not plugged; and
- the material used to make the MSS must be resistant to the material being sampled.

INSTALLATION AND MAINTENANCE

The MSS needs to be installed, operated, and maintained by conscientious individuals with an understanding of basic structural, electrical, mechanical, and maintenance requirements of the MSS or inherent maintenance problems can be exacerbated.

Well designed and well-maintained MSSs are essential in the collection of a sample representative of the lot from which the sample was collected. A poorly maintained MSS will not function as designed and will more likely collect/ process a biased sample.

Careful consideration must be given to who has the responsibility of monitoring and controlling the MSS performance. It is important that the group responsible for quality assurance of the MSS is not the same group that operates it. When the MSS is being operated and maintained by material-handling personnel, whose main job is to move material from point A to point B, the proper operation of the MSS may conflict with their primary function of moving the material. Consequently, MSS maintenance and performance may not be up to expectations.

Likewise, testing the performance of a MSS after installation should be handled by an independent group that is knowledgeable in the nuances of sampler bias testing and quality assurance.

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PERFORMANCE/BIAS TESTING

A bias test can be conducted to demonstrate that the MSS is suitable for use, as a provision for paying the MSS manufacturer for its installation, or as part of an ongoing quality assurance programme.

Such a test is usually preceded by a critical inspection in order to locate obvious areas that need correction before the bias test is conducted. There is no reason to perform bias test upon (or, for that matter, to operate) a system that has obvious faults that may lead to collection of biased samples.

Consequently, a performance test is a simple comparison of the material extracted by a MSS to the material from which it was extracted. In practice, the performance test is complicated by the existence of various statistical models, experimental designs, and interpretative techniques. This article will not attempt to discuss the various options for bias testing, but it is fortunate that ASTM International, ISO and other international standards bodies have documented and discussed various bias testing techniques, most notably for bias testing coal MSSs. The following standards are recommended for reference:

- ASTM D6518-01, Standard Practice for Bias Testing a Mechanical Coal Sampling System; and
- ISO 13909-8:2001, Hard coal and coke – Mechanical sampling – part 8: Methods of testing for bias.

During a bias test, the final MSS sample is usually compared to a reference sample, typically a sample collected using the stopped-belt method.

Usually a minimum of 20 or 30 sets of stopped-belt reference samples and comparison samples (usually final MSS samples) are used to test for bias. Ideally, the final MSS sample will match the characteristics of the reference sample, indicating an acceptable level of performance. In reality, a loosely covered final MSS sample can lead to moisture loss from the collected sample or be accidentally or intentionally contaminated by wash-down water or extraneous materials.

ONGOING QUALITY ASSURANCE PROGRAMMES

Whenever a MSS is put into service or bias tested, the assumption often made is that the MSS will continue to perform in the same manner as it was performing on the day of the installation or bias test.

Ideally, the final MSS sample will match the characteristics of the reference sample. In reality, a loosely covered MSS sample can lead to moisture loss from the collected sample

This is a dangerous assumption to make. MSSs, being mechanical, are subject to wear, require maintenance, and need periodic verifications of their continued capability to operate as designed. It is most definitely a misnomer to refer to an MSS as an "automatic" sampling system. There is nothing automatic about them, except that they will automatically produce a poor sample if left untended and poorly maintained.

Once put into service and shown to be capable, the MSS must undergo frequent surveillance to monitor and control its performance, demonstrating that the sampling system is performing consistently from one day to the next. Commonly accepted methods for monitoring and controlling ongoing MSS performance include periodic critical inspections and the use of Statistical Process (SPC) charts

A minimum of 20 sets of stopped-belt reference samples and comparison samples are used to test for bias.

CRITICAL INSPECTIONS OF MSSs

Every MSS is different – MSSs can be designed to sample different materials; MSSs can be operated differently, e.g. time- or mass-based; MSSs can be constructed using different components, e.g., roll crushers or hammermills, vibratory feeders or belt feeders, etc.; and MSSs can sample different lot sizes, topsizes, feed rates and so forth. Therefore, it is not possible to provide a primer on critically inspecting MSSs that will work in every case. Instead, the following general requirements are offered:

- the inspector performing the inspection must be knowledgeable and experienced;
- records must be made of each inspection;
- where required, corrective or preventive action requests must be prepared to remedy inspection findings;
- as necessary, maintenance requests must be issued:
- photographs of equipment problems should be taken; and
- follow-up is always required to ascertain that the corrective or preventive action or maintenance request has been completed and that the action is effective in correcting the problem identified

Measurements are made of cutter opening widths, speeds, and cycle period and records are reviewed for feed rates, lot sizes, and so on. The theoretical extraction ratio is determined and compared to the actual extraction ratio. If the two values do not agree within 10%, there may be reason to question the measured values or the functionality of the MSS.

PROBLEMS TO LOOK FOR

There are certain things to look for with every MSS inspection:

Cutters: do cutters cut the entire stream of material, extracting a complete cross-section? Is the velocity of the cutter appropriate? Is an appropriate mass of sample collected in relation to the material topsize? Does the cutter divert extraneous material to the save side of the system (delimiting error)? Are a sufficient number of increments collected for the lot size and level of heterogeneity?

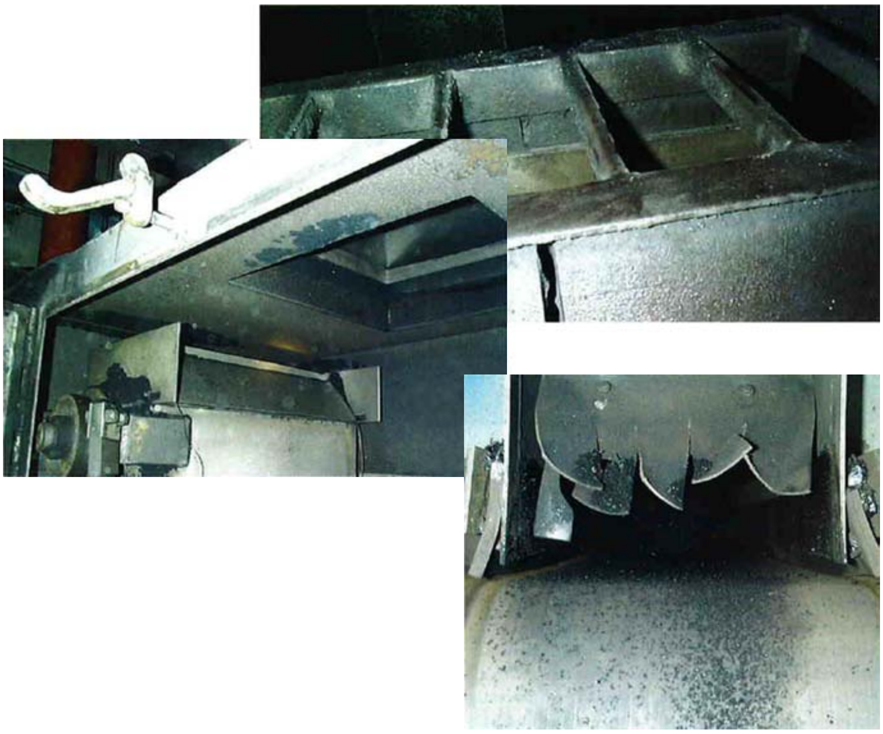
Is the primary cutter free of obstructions, intentional or accidental?

Is the cutter subject to material build-up that can then fall into the save side when the material had been destined for the reject side? Does the cutter have "knife" edges, cut the entire stream, and not allow for misplaced material?

Feeders/conveyors: are air baffles present in feeders/conveyors to help prevent the chimneying of drafts through the system that may dry the sample? Is skirting tight against the belt feeder? Are belt scrapers intact and do they prevent carry-back?

Crushers: Is the right crusher selected for the material? With the proper level of maintenance? Is the crusher product sized periodically to verify adequacy of sample mass being collected and subsequent cutter opening width?

Cutters: these must cut the entire stream of material and be free of obstructions, intentional or accidental.



Feeders/conveyors: these must have air baffles to help prevent the chimneying of draughts through the system that may dry the sample

GENERAL CONSIDERATIONS

Is there evidence that the MSS components have been abused in order to clear plugging? Is the component resplendent with dings, bangs, and bumps? Is there evidence that appropriate levels of maintenance are being conducted, including replacement of filters, fluids, grease, etc.? Is the system airtight? Is it draught free? Are ports kept closed and are they equipped with seals and latches, but still easily accessible?

Are there spills around MSS components that are evidence of poor design or poor maintenance?

Is the system free of standing water – on the inside?

Are components fabricated from corrosion resistant materials? Is the system rather self cleaning or prone to interior build-up?

SPC CHARTING OF MSS PERFORMANCE

SPC charts, in conjunction with periodic critical inspections, are used to give assurance that the same conditions as existed when the, MSS was installed or bias tested actually do prevail throughout the ongoing operation of the MSS. When there are no changes to the MSS operating parameters and to the extraction ration (as demonstrated by the SPC charts for individuals and moving range), it is reasonable to assume that there would be no fundamental change in the operating or bias condition of the MSS.

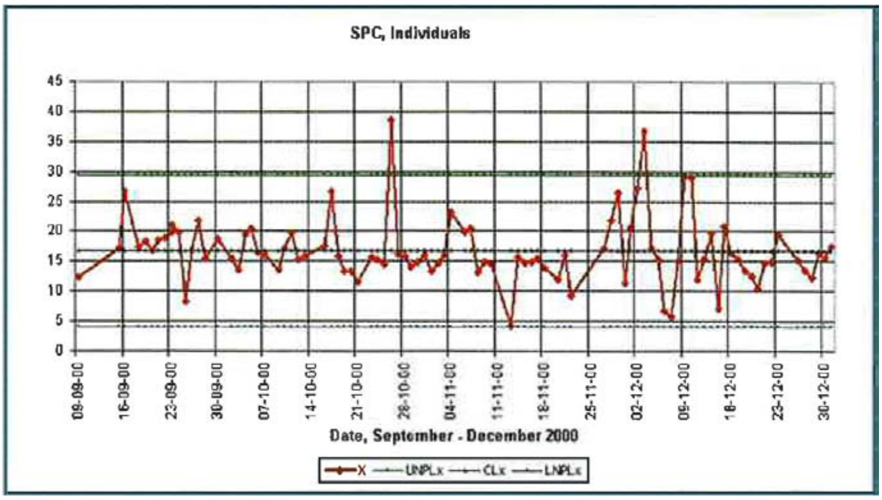
Where there is an excursion beyond an action limit, an investigation into the cause of the excursion is conducted.

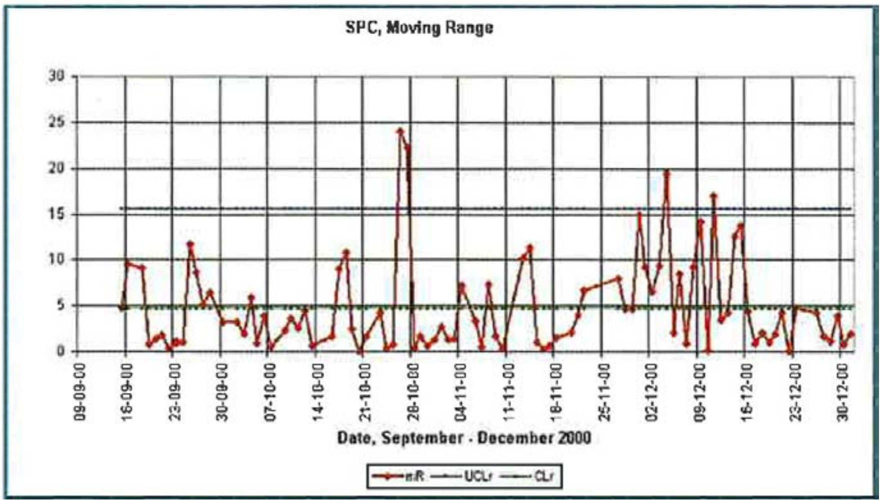
Various other means of plotting the MSS extraction ratio are possible.

- a plot of [actual extraction ratio/ theoretical extraction ratio] "bounces" around 1.00 and
- a plot of the coefficient of variation, a confounding of the two fundamental distribution characteristics of mean (centre) and standard deviation (spread), in which the standard deviation is divided by the mean and multiplied by 100%, is often determined on the basis of 20 rolling data points.

However, plotting and monitoring the SPC charts for individuals and moving range allows one to monitor and control the two fundamental characteristics of any process distribution – its centre and its range. The process centre and the process spread for the "mass of final sample per 1,000 tons sampled" are determined routinely and plotted on SPC charts, which are used to monitor and to control the performance of the MSS.

The "mass of final sample" can be in pounds or kilogrammes and "tons" can be metric tons or short tons. In which ever case, carry out calculations to produce values that are significant, yet sensitive to changes in MSS performance. Remember that a change in extraction ratio can be due to a change in the performance of one of the measurement systems – the balance used to weigh the final sample or the belt scales or draft survey used to determine the tons sampled. If your measurements are too insensitive, a different balance may be needed for weighing the final sample mass.





SUMMARY

The proper sampling of a material is paramount in determining the value of a cargo. Risk associated with inaccurate evaluations of cargo is managed by selecting the proper MSS; installing, operating, and maintain the MSS in a proper fashion; and verifying ongoing performance of the MSS by a bias testing, critical inspections, and SPC charting.

Risk management is an important component of any MSS quality assurance programme and must be assigned to a group that is independent of operations, is experienced, and is knowledgeable about MSS design, operation, and maintenance.

In addition to proper management of the MSS, risk can be further managed by the selection of an appropriate and reasonable sublot size, analysis of sublot samples in at least duplicate, and the reporting of weight-averaged analyses (where appropriate, as some parameters should be tested only on a physical composite).

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