http://dx.doi.org/10.17159/2411-9717/2017/v117n7a4

Design considerations for critical coal measurement points: towards accurate reconciliation for integrated mine planning

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Synopsis

Integrated coal mine planning requires integration of mine planning technical inputs like survey, geology, planning, mining, processing, and finance. A comprehensive strategy on tracking, measuring, and reconciling coal from the mine plan to the customer is needed to achieve this. The ultimate aim is to have confidence in the coal measurement, accounting, and reporting processes so that the effectiveness of the entire planning process can be measured for compliance with business standards. For such leading practice it is necessary to determine measurement protocols at carefully selected measuring points. The design of such critical measurement points to allow for integrity and accurate reconciliation in the context of integrated mine planning is the topic of this article, with reference to a typical surface (dragline) coal mine operation. A general surface coal mine flow diagram was developed. For a flow and distribution system for such a mine, five critical measurement points are expected. These are the output of mine planning and scheduling process; post-mining pit survey and highwall mapping; the quantity and quality of feed material; quantity and quality of coal product; and the coal distribution process which extends from the product to the preparation plant and point of sale to the customer. In order to prevent inherent human errors, key data must be captured and recorded electronically and automatically. A digital mining approach allowing for automation tracking, measuring, reconciling and reporting of coal along the value chain is recommended.

Keywords
integrated mine planning, processing plant, critical coal measurement points, accurate reconciliation.

Introduction

Reconciliation is basically defined as the process of comparing measurements and estimates along the mine value chain at different points in time, for the purpose of tracking and optimization of metal recovery (Marcfarlane, 2013). This implies a need for interaction between people, processes, and systems to enable an efficient and accurate accounting of the metal recovery and commodity of interest. In the broader context of mining, measuring points at which reconciliation may occur are defined for every particular operation. Marcfarlane (2011) outlined a number of reconciliation boundaries required for management control, from the model to the plant delivery. Although several mines have designed specific solutions for performing reconciliation, a systematic approach is usually required to develop and implement a successful reconciliation system. This will enable a better understanding of the flow of material from the source to the plant delivery, where the biggest variances occur, and potential metal losses.

A commodity like coal is either shipped directly to the market or processed first into saleable material according to market specifications. The process of reporting coal through continuous reconciliation between actual coal produced and planned is part of an integrated mine planning process. Measurements are critical for tracking and reconciling coal recoveries and require consistency during measurement, reconciliation, and reporting of coal production. For this to be successful, mining, technical, contractor, and plant personnel must frequently review their measurement systems for monitoring and tracking production from the pit to the customer. Planning and operating practices must aim to improve coal recovery and operational and governance requirements in order to achieve consistency and integrity.

This article discusses the issues to be considered for accurate coal measurement and reconciliation. The following are some of the critical issues that cut across the coal production chain:

- ➤ The integrated mine planning process
- ➤ Critical coal measurement principles;
- ➤ Critical measurement points and reconciliation.

A critical measurement point is defined here as any measurement that occurs in or between processes and ore systems. The objective is to describe procedures for tracking, measuring, and reconciliation at a typical surface coal mine. These need to be based on leading industry practices, but must also suit local conditions.

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The integrated mine planning process

Integrated mine planning is an initiative reflecting an optimized interaction between people, processes, and systems (Cawood and Richards, 2008) for safe, sustainable, and profitable production. Although the process varies in detail from mine to mine, it should follow a basic structure like the one depicted in Figure 1. Cawood and Richards (2007) highlighted some opportunities for coal mine surveyors to add value at the operational and corporate levels of the mining company. These opportunities include playing a role in mineral accounting and quality assurance to meet mine requirements, market specifications, and reporting. Such work must be done in a manner that is consistent with business drivers along the mine value chain.

The planning process begins with the reporting of Resources and Reserves according to the South African Code for Reporting of Exploration Results, Mineral Resources and Mineral Reserves (SAMREC Code). Reserves form the basis of the resource development plan (RDP), which provides the first benchmark for the reconciliation of coal. The RDP is used to identify economic and market criteria. Other inputs such as the mine's corporate strategy also inform the long-term plan. The medium-term plan (5-year business plan) is developed from constant revision of the life-of-mine (LoM) plan, taking into consideration medium-term economic and market criteria, corporate goals, selection of equipment, and the grade control model (GCM). The short-term plan (annual plan) is a refinement of the medium-term plan, plus other inputs such as short-term economic and market criteria, annual corporate goals, equipment updates, scheduling, and the refinement of the GCM. The last stage of the planning process is the budget mine plan (monthly or quarterly) where scheduled blocks (defined by SAMREC as the smallest modelled volume in the Reserves database and lowest scheduling entity in the planning hierarchy) are created with coal quantities and qualities calculated for each block. Adjustment factors are applied to estimate coal resource, (ROM) coal reserves, and marketable reserves. Morley and Moller (2005) categorized these observations in the planning process into four major headings:

- Resource/reserve estimation and mine planning (includes long-, medium-, and short-term planning plus annual reporting and budgeting)
- Mining, which includes resource/reserve block depletion (dispatch, survey data, and stockpiling information)
- Plant processing (feed and product)
- General observations and best practices.

The categories of a planning process outlined by Morley and Moller (2005) and the definition of an integrated mining process by Cawood and Richards (2008) emphasize the need for best practices in measurements.

All activities at every stage of the planning process are reflected in the GCM, which is the best available estimate of the coal to be mined (defined by SAMREC as the coal *in situ* within a scheduling block and within a working section targeted for mining and expressed as *in situ* tons at *in situ* moisture) and the products it will yield. The GCM is therefore fundamental for the comparison of planned and actual mining recovery. A number of opportunities become available to improve the definition of the coal to be mined as operations approach the area of interest. These areas of interest and their descriptions are outlined in Table I.

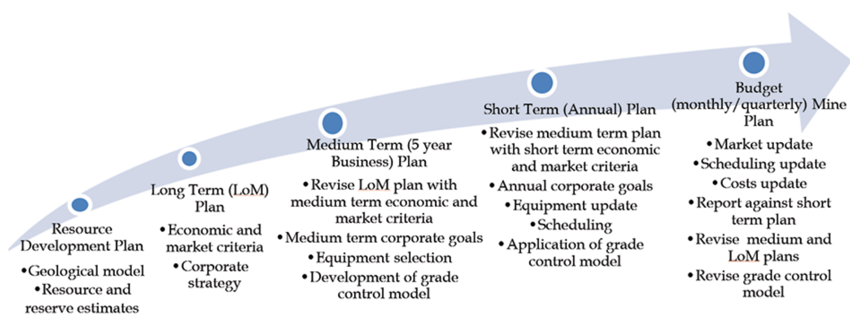

Figure 1—Typical planning process (Cawood, 2015)

Table I

Improving the definition of coal during operations

Area of interest	Description
Highwall mapping	Highwall in the previous strip to be surveyed and mapped to characterize the overburden to be blasted in the next strip. Define the roof and floor horizons for the low wall of the next strip.
Strip survey	Strip surveys for grade control include coal floor profiling, losses underneath roadways, and potential loss due to accumulations against the highwall.
Top of coal drilling and/or strip sampling	Core drilling may be required from exposed coal roof to improve the definition of coal quantity and washability.
Mining practices	Mining equipment and method influence the scale of dilution and loss.
Preparation plant simulation	Available representative washability data from pit sampling or coal drilling will enhance the short-term estimation of preparation plant yield.

Design considerations for critical coal measurement points

Coal Resources form a subset of the total tonnage of coal *in situ* (defined by SAMREC as coal in the ground, before exposure and at *in situ* moisture and density). In terms of SAMREC, the Coal Reserve is the economically mineable subset of the Coal Resource. An economic mine plan and a series of adjustment factors are required to generate Coal Reserves (ROM tonnages) and Marketable Reserves from the Coal Resource. The adjustment factors used need to describe what is expected in terms of mining and preparation plant recovery for coals from different parts of the Resource. The relationship between Coal Resources and Coal Reserves is illustrated in Figure 2.

Mineable *In Situ* Coal Reserves are subdivided, taking into consideration an increasing level of geoscientific knowledge and confidence, into Probable and Proved Mineable *In Situ* Coal Reserves. ROM Coal Reserves are further subdivided into Probable and Proved ROM Coal Reserves, also with increasing level of geoscientific knowledge and confidence.

The calculation of quantity and quality of the ROM Coal Reserves takes the following into considerations:

- Mass (tonnage) after allowing for geological losses, mine planning factors, moisture content, mining losses, mining dilution (defined in SAMREC as the waste material that is mined during mining operations and thereby forms part of the Reserve), and contamination
- The quality of the coal, expressed in parameters relevant to specific applications for *e.g.* Eskom coal, Export coal. Additional quality specifications include ash, volatile matter, sulphur, coking properties, calorific value, *etc.*

Saleable Coal is the tonnage and quality of coal available for sale, either in the raw ROM state, at a specified moisture content, or after beneficiated ROM Coal Reserves have produced materials at specified qualities, moisture contents, and size ranges. For raw ROM products, the practical product yield is typically 100%. Discard and Reject Coal (defined by SAMREC as coal or any carbonaceous material from coal processing or mining operations with quality parameters that are not within the current range of saleable coals) from the processing plant or mining operations should be measured for effective coal flow comparisons and reconciliations. Figure 3 shows the basic relationships that need to be addressed.

The outer and larger circle represents the *In Situ* Coal Resource. Some of this may be uneconomic or unmineable and is therefore excluded from the coal identified for mining. Adjustments are applied to the quantities and qualities of the coal represented by scheduling mining blocks as part of the planning process. Such mining blocks are informed mainly by the mining method that is applied. The mining process will inevitably fail to recover all of the targeted coal in a block and will include some dilution from adjacent materials. This mixture then becomes the ROM coal that is removed from the pit. ROM coal may be placed in an intermediate stockpile and later reclaimed before being fed to the plant or power station, either alone or in a blend consisting of coal from another mining area or areas.

The first beneficiation process usually involves crushing the coal in a rotary breaker, which also separates large hard fragments as reject. The remaining material is then stockpiled as crushed coal and is subsequently reclaimed as the feed to the preparation plant. The breaker reject and the yield expected from the preparation plant must be estimated for each scheduling block, based upon the relevant properties of the coal and dilution materials. Simple adjustment factors based on available borehole core samples tend to be used, in conjunction with broad efficiency factors, to generate estimates of the marketable reserves. Adjustment factors are often used in the industry to obtain a reasonable estimate of Saleable Reserves (represented by the smallest circular shape in Figure 3, called the yield). However, the general nature of these adjustment factors makes it difficult to back-analyse the performance of discrete processes or to guide specific improvements of field performance. The condition of coal is altered as it undergoes mining, handling, treatment, and transport. Other processes such as breakage, losses, contamination, and exposure to the ingress of moisture are all possible means of altering the characteristics of the coal. These effects need to be evaluated for every coal type and at all stages of the coal flow.

The next section will discuss measurement principles and requirements for ensuring that coal production is measured and reported along its critical measurement points from mining to market towards accurate reconciliation.

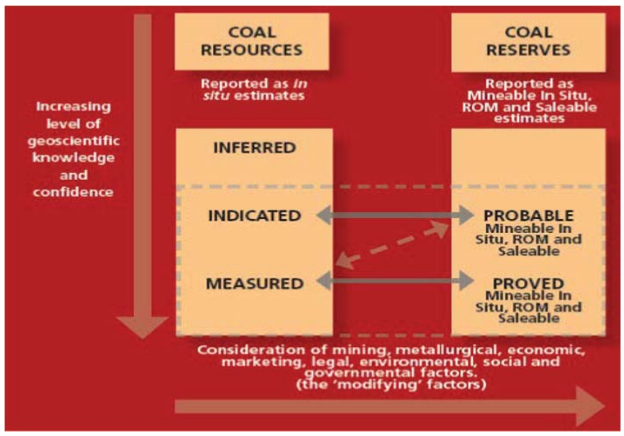

Figure 2—Relationship between Coal Resources and Coal Reserves (Source: SAMREC Code, 2016)

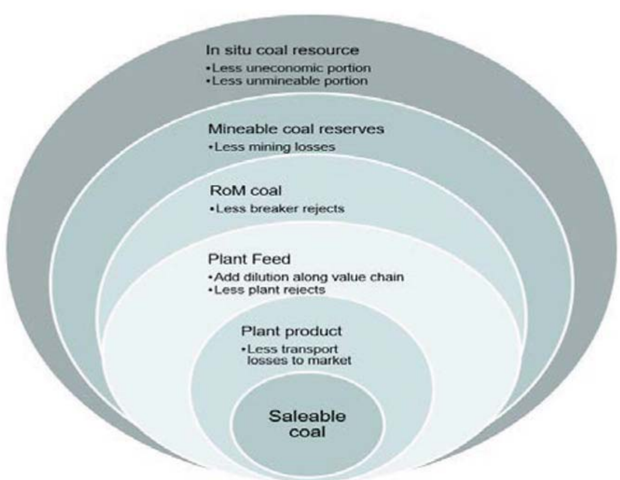

Figure 3—Transition of coal from *in situ* to saleable tonnage

Design considerations for critical coal measurement points

Critical measurement principles for accurate reconciliation

There are some basic measurement principles that need to be adhered to for ensuring reliable information is always produced throughout the coal value chain. There are many challenges in obtaining adequate measurements, which include capital cost of equipment and maintenance thereof, human resources, analysis and reporting of measured data, and assigning areas of responsibility. The measurement variables and their descriptions in Table II highlight some of the basic principles that need to be adhered to if a measurement system is to produce reliable information.

The measurement variables and descriptions in Table II are important to highlight efficiencies in the mining process. These would enable the reconciliation in the coal mining process. The accuracy of these measurements will help to bring out the 'truth' in the reconciliation results.

Measurements for meaningful reconciliation

Production monitoring and reporting outputs are needed for a successful reconciliation of coal recovery and mining performance against the actual plan. The following production measurement and reporting outputs are essential requirements for the successful reconciliation of coal recovery and mining performance against plan.

Requirement 1: Design of the critical measurement points

This is a major decision because it will require location of critical measurement points for meaningful reconciliation. Part of the design will include protocols and standard operating procedures (SOPs) at each measurement point. The design must also take the allocation of resources and budget constraints into account. Five critical points have been identified for a surface dragline coal mine operation to ensure effective control.

1. *Output of the mine planning and scheduling process*—Considers the estimate of coal resources and reserves per mining block after the GCM has been applied to it. The outcome (for reconciliation back to plan) is a short- to medium-term statement on the locality, quantity, and quality of planned coal over specific periods. The information compiled for this purpose must also meet the reporting requirements of the plant.
2. *Post-mining pit survey and highwall mapping*—This is the actual tonnage mined (defined by SAMREC as the actual volume of ROM coal washed and processed from ROM coal fed to plant over a specific period) as calculated from survey measurements done according to the mine's SOP. This does not include sampling to test the quality of the coal. However, the sampling of exposed coal will result in better certainty on the quality of coal delivered to the plant and hence enable the plant manager to plan for better product control. The reconciliation on quantity (volume and/or mass) will be in both directions, *i.e.* with planned coal and coal delivered at the plant
3. *Feed tonnage (ROM coal) and quality delivered to the plant*—These include the consideration of various measurements – on-mine stockpile surveys, coal quantities delivered to the plant but not fed immediately into the plant, truck tallies, and truck weighbridge and conveyor scale readings. The calculation includes reconciliation of mine stockpile surveys against post-mining pit survey results and ROM coal to plant against the weighbridge at the plant. This point will also consider only the mass and not include sampling – similar to the second critical measuring point
4. *Coal product tonnage and quality*—This will be determined from a combination of stockpile surveys and scales for mass, in addition to the quality parameters reported by the plant. Coal stockpile areas are typically surveyed by the plant surveyor and checked by the mine's surveyor. It is important to note that this may be the first time that the quality parameters of the coal will be compared with the planning output if samples are not taken at measurement point 2
5. *Coal sales tonnage*—This is a final measurement of mass from mechanical scales recording the tonnage that leaves the plant. These scale readings will be

Table II

Considerations for applying the principles of measurements

Measurement variables	Description
Mass and quality	These are coal parameters that need to be measured and tracked through the value chain.
Moisture	The weight of coal is meaningful only if the moisture content is known. Many of the ore loss, dilution, and recovery impacts that need to be understood and managed can be disguised by changes in moisture, which varies between 2% and 10% depending on season and location along the chain of production processes.
Accuracy and uncertainty	Measurements are subject to some level of uncertainty. These uncertainties are propagated through the production chain. A better understanding of accuracy and reliability of measurements allows a better accuracy when balancing calculations and a better interpretation of the numbers. For instance, survey results are preferred above those obtained from mechanical scales, and mechanical scales preferred above truck counts and truck factors.
Stockpile measurements	Stockpile measurement is a challenge. The traditional way of dealing with stockpile measurements is to acquire frequent reliable measurements of the stockpile volume and add or subtract measurements based on the most reliable stockpile information available. Unmanned aerial vehicle (UAV) technologies can now provide accurate, frequent updates.
Sampling	Quality estimation at any stage in the coal production process depends largely on sample representativeness. When considering the reliability of the results, it is important to note that it may not be possible to meet all the statistical requirements for sampling at some stages of the process.

compared with product stockpiles (backward) and other (forward) measurement points closer to the markets.

Figure 4 illustrates a typical flow sheet (of a surface coal mine) for the passage of coal from the ground to the point of delivery in the plant. Although this may vary from mine to mine, the same measurement principles are applicable. A number of critical measurement points are identified in the flow sheet indicating where tonnage and quality are measured in order to quantify mining performance and for reconciliation purpose.

Requirement 2: Identification, locating and tracking of coal

This starts with mining block identification as developed by the short-term planning process. Coal from each scheduling block is tracked through the mining, handling, and preparation plant processes. Unforeseen conditions and departures from the planned operations are noted and interpreted for performance. The physical factors that affect the recovery of coal, such as geological structures, geotechnical collapse, or practical mining issues, must be identified so that their impact can be separated from more routine measures of mining performance.

Requirement 3: Applying the principles of measurement correctly

The measurement principles required to ensure reliable information are applied throughout the coal value chain. Measurement errors should be reduced to a minimum. Possible sources of error include:

- ➤ Accuracy with regard to sampling
- ➤ Survey measurements, with specific reference to stockpiles
- ➤ Volume calculations of mined areas
- ➤ Errors accrued in measuring additional quality specifications such ash, vitality, density, moisture content, calorific value (CV), coking properties *etc.*

Requirement 4: Reconciling at each measuring point

Reconciliation is achieved by a structured comparison between the planned and actual values at each measuring point. Time-based production measurements will have to be adjusted to represent the performance of the same blocks of coal at different stages in the production process. It is recognized that the current planning and measurement systems at each operation may not be able to meet all of the requirements listed here. However, the progressive installation of additional measuring equipment and the reporting of basic reconciliations will quickly identify areas requiring additional resources, and will contribute to the ongoing refinement of the mine's protocols. The extent to which this comparison can be undertaken is limited only by the extent and reliability of the measurement data and the resources available to undertake the exercise. Riske *et al.* (2007) emphazised the need to capture key data through electronic and automatic means to eliminate human errors.

The next section outlines specific critical measurement points that exist along a typical coal production value chain. These critical measurement points are necessary to enable a successful reconciliation to be undertaken for effectivene planning and efficiency of mining operations.

Critical measurement points and reconciliation

For a typical surface mining, processing, and coal distribution system, taking into consideration the market requirements and mining areas serving a processing plant, the following critical measurement points are expected:

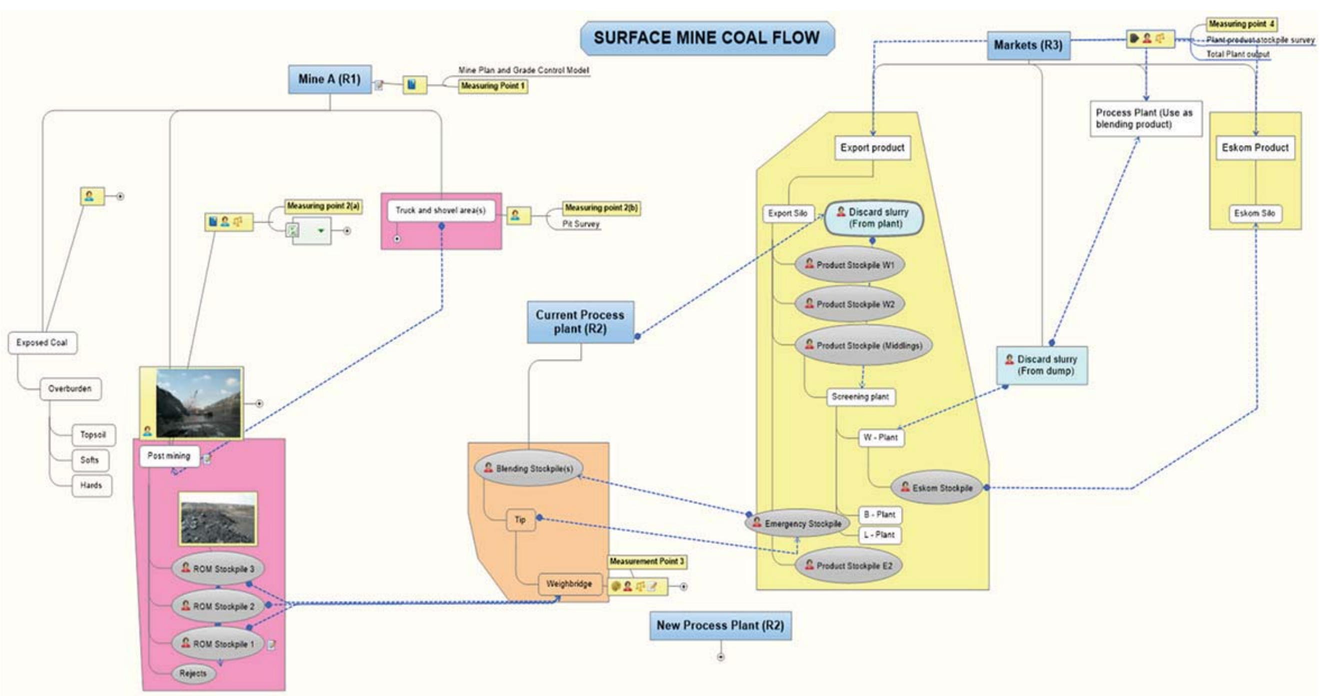

Figure 4—Typical surface coal mine flow sheet

- *Critical measuring point 1*—Output of the mine planning and scheduling process
- *Critical measurement point 2*—Post-mining pit survey and highwall mapping
- *Critical measurement point 3*—Feed ROM tons delivered to the plant
- *Critical measurement point 4*—Coal product
- *Critical measurement point 5*—Coal sales tonnage.

Table III summarizes these critical measurement points with specific reference to the measurement variables at each critical measurement point, data processing technique, and the reconciliation and reporting procedures carried out for the purpose of developing a protocol at each critical measurement point.

Critical measurement point 1 entails the definition of the *In situ* Coal and Reserves. This is the fundamental source of quantity and quality of the *In Situ* Coal and Reserves and Marketable Reserves estimated for a particular mining area. Once the coal has been exposed, surveyors can measure its actual volume and make a detailed quality measurement. At critical measurement point 2, the actual coal mined is obtained by surveying the final floor, highwall, and lowwall edges after mining is completed. Extreme care should be taken to account for any coal losses for the purpose of reconciliation. The third critical measurement point takes into consideration the quantity and quality of feed material. Sources of this data include truck counts, fleet management system, stockpile surveys, and rehandled coal. At critical measurement point 4, the tonnage and quality of the coal product is accurately determined. Very high-quality weightmeters and moisture and ash gauges are used in addition to sampling stations to determine the quality of the coal product, which is monitored constantly to meet market requirements.

Coal sales tonnage (critical measurement point 5) takes into consideration the coal distribution process. This distribution extends from the product at the preparation plant to the point of sale to the customer. This may be delivery on board a ship or to a stockpile at a power station. At every critical measurement point, accurate tonnage and quality measurements are required, taking into consideration the various processes the coal would have undergone.

Conclusion and recommendations

This article described the protocols for tracking, measuring, and reconciling in coal for an integrated mine planning process. A typical planning process begins with the reporting of Resources and Reserves based on the SAMREC Code. The measurement principles and requirement discussed enable accurate key data, such as quantity and quality, to be captured for accurate reconciliation of coal from the In-situ Coal Reserve to saleable coal. It is, however, necessary to develop detailed protocols at each of the five critical measurement points discussed in this article, namely:

1. The output of the mine planning and scheduling process
2. Post-mining pit survey and highwall mapping
3. Feed tons delivered to the plant
4. Coal product
5. Coal sales tonnage.

The authors recommend that measuring protocols at each critical measurement point should be regularly reviewed and updated. In order to reduce errors accumulated in the collection of key data, automatic and electronic means for capturing data are recommended. To carry out a routine reconciliation process at a typical surface coal mine, it is necessary to arrange site meetings with management and senior technical personnel to ensure that management is supportive of the process and willing to initiate the process. Creation of awareness of the reconciliation programme, requirements, and procedures is necessary at all levels of the operation. A digital mining approach that enables the automated tracking of quality and quantity data through sensor technologies is recommended. Further reconciliation and reporting of coal along its flow would be possible through a web-based digital mining data system.

Acknowledgement

The authors gratefully acknowledge the support received from the Wits Digital Mining Research Group, Julian Baring Fund, and the Wits School of Mining Engineering.

References

Cawood, F.C. 2015. Reporting of coal reconciling planned with actual. Sandvik International Mining School, University of the Witwatersrand.

Cawood, F.C and Richards, W.J. 2007. A review of the role of the coal mine surveyor in South Africa. *Journal of the Southern African Institute of Mining and Metallurgy*, vol. 107. pp. 109–113.

Cawood, F.C and Richards, W.J. 2008. Standardisation and formalising technical inputs into the mine planning process: A coal mine example. *Journal of the Institute of Mine Surveyors of South Africa*, vol, XXXII, no 9. pp. 659–673.

Marcfarlane, A.S. 2013. Reconciliation along the mining value chain. *Journal of the Southern African Institute of Mining and Metallurgy*, vol. 113. pp. 679–685.

Marcfarlane, A.S. 2011. Reconciliation along the base metal value chain. *Proceedings of the 6th Southern African Base Metals Conference*, Phalaborwa, South Africa, 18–21 July 2011. Southern African Institute of Mining and Metallurgy, Johannesburg. pp. 429–442.

Morley, C. and Moller, R. 2005. Iron ore reconciliation – a case study from Sishen Iron Ore Company. *Proceedings of the Iron Ore Conference*, Fremantle, Western Australia, 19–21 September 2005. Australasian Institute of Mining and Metallurgy, Melbourne. pp. 311–318.

Riske, R., Froud, J., Morley, C., and Gotte, J. 2007. The implementation of Snowden Software - a case study from Telfer. *Proceedings of the World Gold Conference*, Cairns, Queensland, 22-24 October 2007. Deschenes, G., Tuckerm D., Pocock, K., and Avraamides, J. (Eds.) Australasian Institute of Mining and Metallurgy, Melbourne. pp. 75–82.

SAMREC. 2016. South African Mineral Resource Committee The South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves (the SAMREC Code). 2016 Edition. Prepared by the SAMREC Committee under the Joint Auspices of SAIMM and GSSA). ◆

Table III

Critical measurement points in a coal mine

Critical measurement point	Measurement variables	Processing	Reconciliation	Reporting
CMP1- Output of mine planning and scheduling process	Tonnage, quality and locality of planned coal. Mine plan and grade control model – Area, volume/mass, relative density, losses and dilution, quality parameters such as CV, ash content, and moisture content	Volume of coal *in situ* obtained by multiplying modelled block plan area by the vertical thickness. Volume of coal in ground is same as volume of coal at *in situ* moisture. Esitmation of loss and dilution measurments of coal mass accompanied by moisture content and then mass of coal minus moisture to be determined. Coal density is obtained from the exploration borehole core samples. *In situ* mass of coal is calculated from *in situ* volume of coal and RD of coal at *in situ* moisture. Appropriate adjustment of ROM coal is first to estimate the mass of *in situ* coal and then consider any moisture adjustments gained or lost from the *in situ* to ROM.	Comparison of grade control model to coal reserves.	Production planning information generated by the mine planning department. Report generated at start of each month and contains information per seam and mining block
CMP2- Post- Mining Pit survey and highwall mapping	Volume/Mass of coal and waste material. Surveying and mapping of final floor, highwall and lowwall edges after minng. Swell factors to ensure true low wall edges and seam floor are measured. Quality parameters from sampling of exposed coal (moisture, loss and dilution).	Processing of ROM moisture content usually greater than *in situ* moisture content. The values of loss and dilution thickness are determined based on a back-calculation of previous mining supported by detailed surveys of mining operations. Issues to consider in estimating loss and dilution thickness are overcleaning possibilites, coal left behind, mining equipment used and blasting leading to loss and dilution, wet working areas will tend to increase both loss and dilution.	Comparison of ROM production to grade control model. This measurres the efficiency of the mining process. Comparison of ROM ash to *in situ* ash. Determination of apparent minng recovery (Compares ROM tonnes to *in situ* tonnes.	Tracking and reconciliation packages such as QMASTOR and Mine Track have been identified. These are used to capture production data. Existing systems are capable of acquiring, validating and reporting production data needed to perfom reconciliations required for reserve to customer
CMP3 - Feed tons delivered to the plant	Feed tonnage and quality. These include mine stockpile surveys, coal concentrations, delivered to plant and not immediately fed into the plant, truck tallies, weighbridge and conveyer scale readings. Truck tallies are compared with weighbridge readings. High-quality weightometer, moisture guage, ash guage and automatic mechanical samplers are required to monitor plant feed. The following parameters must be considered for all ROM sources. Volume/mass of ROM coal, level of foreign material in the ROM coal, moisture, ash, calorific value and size.	Volumes are calculated based on mine's standard and software programme. Variance in volumes should not exceed 5%. Analyses perforemed should include ash, moisture, size, washability by size, coking properties and contaminants. Consider monthly processsing plan and weekly processing schedules. All protocols to be observed. Ensure there is no mixing up of coal from different sources.	Comparison of plant feed to grade control model. Properties of plant feed in the grade control model are compared with the properties of the plant feed to assess the suitability of assumptions and adjustment factors used to generate GCM estimates. Dilution included during mining coal and actual mining recovery are also compared with GCM estimates.	Development of coal tracking and stockpile management systems
CMP4 - Coal product	Coal product tonnage and quality. Accurate measurements of coarse plant reject, moisture and ash content are required to interprete plant performance. Parameters required for accouting purposes are mass, yield, ash, calorific value and size.	The moisture content of washed coal is greater than the ROM coal. Processing of washabilities, ash, CV and inherent moisture should be in accordance with existing sampling and analysis protocols. Consider rotary breaker losses, processing of feed coal quality should be described in terms washabilities of the source coals and dilution materials in appropriate size fractions. Other considerations are processing preparation plant yield and blended feed and product quality.	Reconciliation between plant product and plant feed. This provides a measure of the efficiencyof the coal washing process. All existing protocols should be adhered to.	All protocols to be observed. For *e.g.* the weighing protocols of the two major companies requiring the product coal and discards to be weighed according to minimum specifications on daily basis
CMP5 - Coal sales tonnage	Coal sales tonnage at the market points. Accurate tonnage is required to guide the reconciliation of coal production and creation of coal parcels for sale. Transportation protocol of coal must be adhered to. Measurements are required for calculating clean coal volumes at silos and stockpiles. Coal from different sources are not to be mixed and same applies to coal for different purposes such as domestic and export.	Sampling and analysis protocols to be follwed. For *e.g.* analyses to be performed on coal product on trains. These include export coal trains: CV, total moisture and sulphur. Domestic coal trains: CV, total miosture, sulphur, abrasive index, hardgrolve index and sizing.	Comparison of coal sold to marketable reserves. Includes coal produced and sold from a giving mining area. This also validates the assupmtions used to estimate the marketable reserves.	Apply existing protocls for *e.g.* Plant must prepare a reconciliaton report at end of every month with the following: comparison of ROM coal versus throughput, reconciliaition of metallurgical balance, reconciling ROM coal with clean coal, reconciling predicted with actual yields, reconciling losses with discard materials and explaining deviations and investigating losses.