# REAL TIME ANALYSIS OF CONVEYED MATERIALS FOR PROCESS CONTROL

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## ABSTRACT

*Natural resources by their nature vary in quality. Measuring the consistency of the quality is important as it impacts on processing operations and product quality. Sampling methods have been traditionally used to quantify the changes in quality with the information being used to "control" processing. A major problem is the ability to take representative samples of conveyed flows, especially of coarse materials, and produce timely results for effective process control. Moisture content and its variability are easily measured yet often neglected despite the significant impact on transport costs and materials handling.*

*A range of technologies has been developed that enable conveyed flows to be analysed in real time with minute by minute results available for real time process control. The technologies allow the quality to be measured accurately, continuously and without contact. The results are available in real time and this allows the operations to exercise a much higher level of control on the handling and processing of the materials.*

*This paper describes some of the real time analyser technologies produced by Scantech International Pty Ltd and the benefits obtained by plants in the coal, power, cement and minerals industries that use them. Elemental and moisture analysis technologies are discussed in some detail. Other technologies that are available and their typical applications are also outlined. All technologies are well proven and over 850 analysers have been supplied in over 50 countries.*

## INTRODUCTION

Natural resources exploited through mining and processing operations contain inherent quality variability. Most sample systems do not "see" enough of the flow to quantify the variability or provide analytical results in a timely manner to permit effective process control.

The main components of a flow usually measured are the mass, using a belt weigher, and the quality, typically elemental content determined from a physical sub-sample analysed in a laboratory. The importance of moisture content and its variability are often underrated as it rarely contains valuable components, can affect material handling and is a significant component of the cost of transport and treatment.

Process plant designs that are based on an average quality tend to perform optimally when the average quality is consistently received and there is low variability. Increased variability results in reduced recovery, even if the average quality is the same. Unless the variability is measured it can not be identified and controlled. Real time process control has proven essential to optimise treatment where material quality is variable.

Some of the technologies will be briefly explained and followed by some industry examples outlining the benefits achieved through the use of the analysers.

## TECHNOLOGIES

The paper focuses on the following two technologies:

- elemental analysis using PGNAA (prompt gamma neutron activation analysis), and

- moisture analysis using microwave technology.

Scantech's PGNAA elemental analyser system is unique in a number of ways. The patented non contact configuration allows continuous full stream analysis without any contact with the belt or its load. The use of BGO (Bismuth Germanate) detectors, latest DMCA electronics, proprietary software, remote access capabilities and minimum two year warranty ensures optimum analyser performance for many years of reliable operation.

The PGNAA system involves the use of a small Californium-252 source housed beneath the conveyor. The neutrons emitted from the source are absorbed by elemental nuclei in the conveyed material and excitation causes prompt gamma rays to be emitted. These are measured by an array of multi-spectral BGO detectors housed above the conveyor belt and resultant spectra are analysed, in conjunction with belt load compensation information, to derive the relative abundance of each element. A moisture analyser input is used to correct the tonnages and consequently dry weight percent elemental composition (element or oxide format, ratios, etc) is transmitted to the site control system for trending and display. Operators can manually respond or automate plant responses to achieve real time process control. PGNAA technology is utilised in the COALSCAN 9500X, GEOSCAN-C and GEOSCAN-M models used in the coal, cement and minerals applications, respectively. A typical installation is shown in Figure 1.

Free moisture content is determined by measuring the phase shift and attenuation of a weak microwave field. The dielectric properties of the water allow it to be distinguished from the other material on the conveyor. A belt weigher or bed depth indicator is used for tonnage weighting of the moisture results. The bed depth and material type determines which model of moisture analyser is most suitable for an application.


Figure 1. Elemental analyser and moisture monitor installed in an iron ore processing plant.

Other technologies in Scantech's range of real time analysers include:

- DUET (dual energy gamma transmission), used for ash measurement in coal,
- natural gamma, used for ash in coal, iron ore and uranium ore quality measurement,
- fast neutrons, used in conductive materials moisture analysis,
- microwave resonance, used in the Carbon In Fly Ash (CIFA) analysis.

The real time analysers:

- do not contact the conveyor belt or the transported load
- are not affected by belt speed, particle size, or bed segregation
- analyse the full depth on the bed
- analyse the whole stream continuously
- utilise belt weigher input for tonnage proportioning (weighting)
- transmit results to the plant every few minutes for process monitoring and / or control.

All analysers (except the CIFA) are for conveyed materials. Further detailed descriptions of the technologies can be found in Edwards (2001). Blenkinsop and Lombard (2003) explain how the technologies are applied in a coal plant. Harris, Smith and Rossi (2005) outline benefits of the technologies in a cement application. The impact of on-belt analysis for emission control in a power station is discussed in Hennessy, Pain and Edwards (2007). Kurth (2007) discusses the applications of the analysers for measuring mine output in terms of process control for both the mine and the processing operations. Kurth and Edwards (2008) provide further case studies of the PGNAA and microwave technologies in the coal, cement and minerals industries.

## CASE STUDIES

Case studies cover the coal, power cement and minerals industry sectors. Users of these technologies wish to remain confidential for commercial and competitive reasons and therefore limited details of the applications are included. Actual plant data is shown and demonstrates how real time analysis has improved the plant operations.

### Coal Processing Plant

The plant mines and processes coal for export. The site’s standard sampling procedures were used to evaluate the COALSCAN 9500X for ash analysis. Samples were collected from the belt every few minutes and split into two streams. One stream was collected as a single daily composite sample and analysed in the laboratory. The second stream was collected in hourly increments and each hourly sample sent to the site laboratory for analysis. Results were tonnage weighted to derive an average daily throughput quality.

A daily average quality was derived from the COALSCAN 9500X which analysed the whole flow continuously and used belt weigher inputs to weight the results. Results of the three sources of analyses over a three month period representing nearly 700,000t of coal are shown in Figure 2.

The sampling data was previously considered representative and decisions relating to the quality of each day’s production were made on the basis of the previous day’s composite sample results.

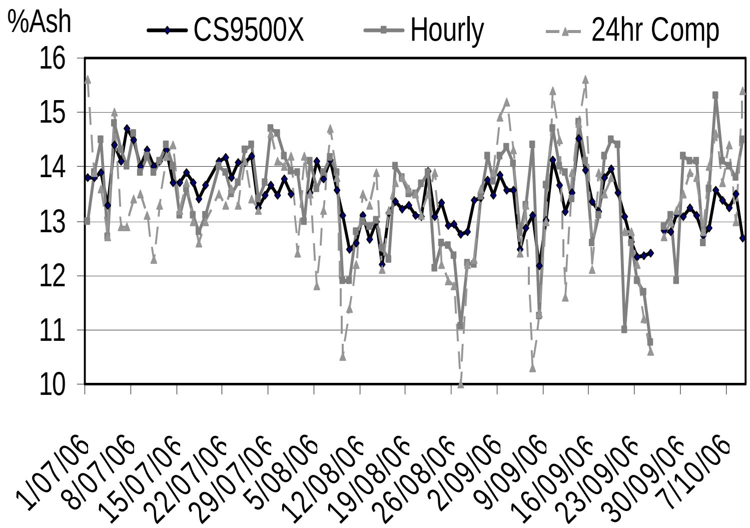


Figure 2. Comparison of analyser data with sampling data for ash in coal.

The following observations were made:

1. the daily composite sample results displayed the most variability
2. tonnage weighted hourly results showed lower variability than daily composites
3. tonnage weighted COALSCAN 9500X averages were the least variable

The daily composite sample was analysed once so all sample preparation, laboratory and analysis errors are attributed to one sample. Tonnage weighted hourly sampling results were averaged over each day, reducing the variability. The COALSCAN data was least variable due to the minute by minute weighted averaging of analyses covering each 24 hour period.

Over a six month period the standard deviation (variability) of the daily composite analyses was 1.2% ash compared with the COALSCAN 9500X standard deviation of 0.6% ash. The result has cast doubts on the suitability of using daily composite samples as the basis for stacking and blending of coal. Evaluation work confirmed COALSCAN 9500X results to be accurate and that daily composite analyses are less representative of the composition of the whole stream. Hence there has been a significant increase in the reliance on real time analysis at this site and fewer problems with stockpile quality management.

**Coal Fired Power Station**

Using a COALSCAN 9500X in a coal-fired power station has demonstrated significant benefits in determining coal quality variation and providing flexibility in utilising poorer quality coal.

Coal for the power station is sourced from a nearby colliery which maintained that the coal quality was consistent due to blending operations and sampling systems. Power station performance did not seem to reflect the claim of consistency in quality of the coal. The power station can react quickly to short term coal quality variability as some boilers are able to burn the poor quality coal while others would stop if the supply of poor quality coal lasted for up to a few hours at a time.

Moisture variability was also of concern in material handling and free moisture levels in excess of 10-11% resulted in chute blockages which caused the power station to shut down until coal supply was re-established.

A COALSCAN 9500X was used to identify quality variability through real time analysis. Analyser results shown in Figure 3 clearly indicate that despite the average coal quality meeting the specification based on daily samples at the mine, there was sufficient reason for concern at the power station due to short term quality variability.

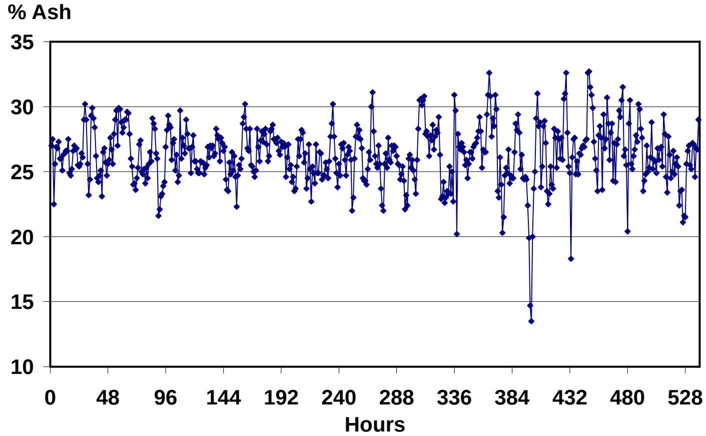


Figure 3. Hourly results from the COALSCAN 9500X showing coal quality variability.

The benefits of the real time analysis for monitoring incoming coal quality include:

1. improving consistency of coal quality received by the power station by blending coal at the mine or at the power station
2. directing poor quality coal to specific boilers, reducing boiler shutdowns and increasing plant performance
3. improving control over moisture content to reduce chute blockages and maximise coal supply availability.

**Cement Plant**

Limestone is used in the cement plant and is dosed with additives ($SiO_2$, $Fe_2O_3$ and $Al_2O_3$) during reclaim of stockpiles to achieve the correct raw mix feed chemistry conveyed to a bunker. The sampling system involved frequent collection of samples and laboratory analysis on site to control the process in batches. Availability of sample analyses was considered a key factor in the quality control system on site. The “sampling system” availability was typically 75% to 80% during plant operation. Improvements were sought to increase analysis data availability and the effect of introducing a GEOSCAN-C to the plant in 1998 is shown in Figure 4.

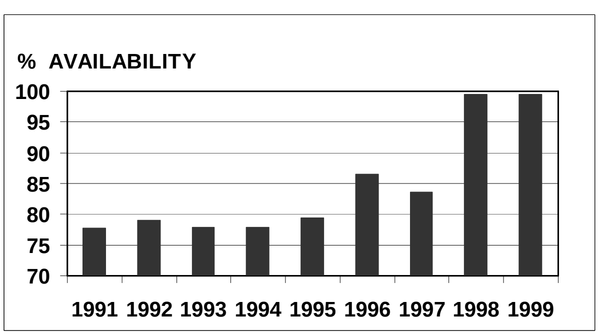


Figure 4. Availability of the analysis data for quality control improved dramatically with the introduction of a GEOSCAN-C on belt analyser.

Following the introduction of the real time GEOSCAN-C analyser in 1998 the quality of material reporting to the bunker significantly increased and quality variability decreased. The standard deviations of the calcium and silicon oxides in the bunker material are the primary measures of consistency of quality at this site. The standard deviation in CaO content fell from >0.9% to <0.5% and the standard deviation in $SiO_2$ content fell from 1.3% to <0.5% as shown in Figure 5. The improved consistency of the raw mix quality has resulted in more consistent cement quality.

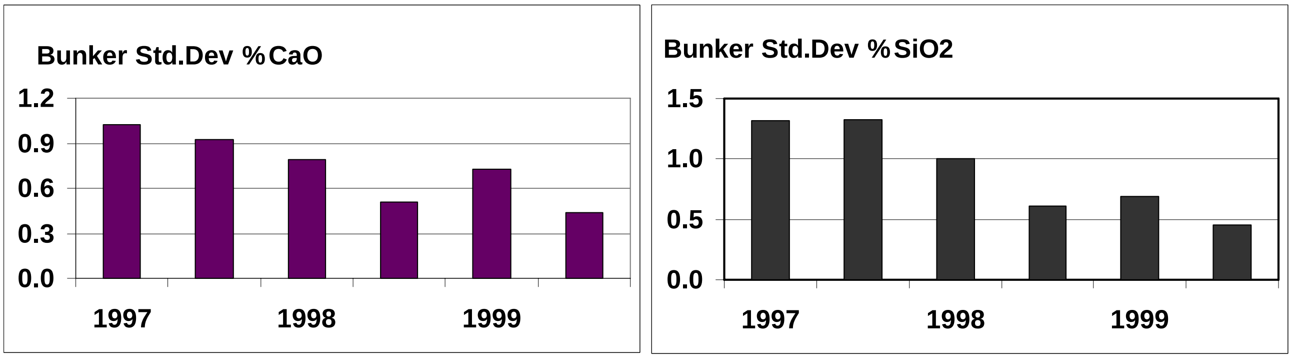


Figure 5. CaO variability reduced significantly and $SiO_2$ variability more than halved following the introduction of the GEOSCAN-C.

**Minerals Plant**

The site processes a metalliferous ore at multiple mines to produce a beneficiated bulk product. Company-owned laboratories “B” and “M” were used to evaluate the GEOSCAN-M performance. The whole flow of material passed through the GEOSCAN-M analyser before the conveyed stream split into two. One conveyor passed through sampling tower “N” and the other through sampling tower “G”. Lag times between the analyser and the two towers were measured to ensure all samples related to the corresponding GEOSCAN-M analysis intervals. Samples from each sampling tower were split in two and labelled B or M. B samples from both towers were sent to laboratory B and M samples to laboratory M. Consequently any batch of conveyed ore was analysed by the GEOSCAN-M and had four laboratory analyses for the same elements.

When the results were compared for the primary metal, the best correlations occurred between the samples from both towers in the same laboratory and the Standard Error was 0.40%. Figure 6 shows laboratory B results and corresponding GEOSCAN-M analyses. Figure 7 shows laboratory M results and GEOSCAN-M analyses.

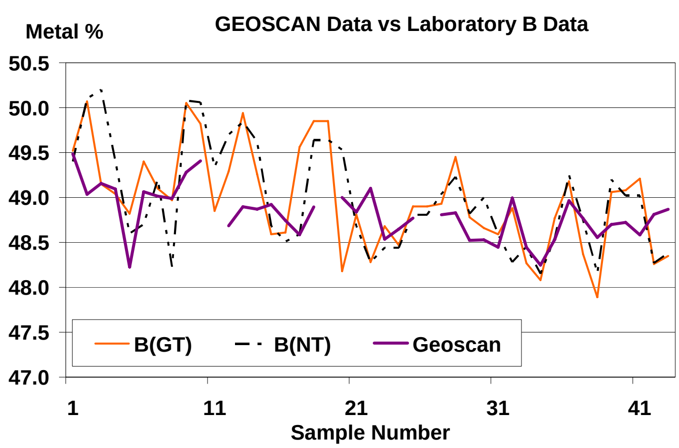


Figure 6. Laboratory B results for both tower sample sets compared with GEOSCAN-M.

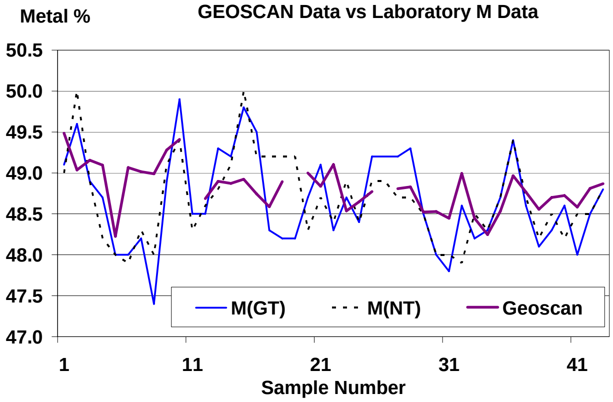


Figure 7. Laboratory M results from both tower sample sets compared with GEOSCAN-M.

Between laboratories the Standard Error was 0.58% for tower N samples and 0.67% for tower G samples. Results from tower G samples analysed in laboratory B are normally used for process control. The Standard Error between the GEOSCAN-M results and the reference results was 0.47%. As this value was low, a high level of confidence was able to be placed in the GEOSCAN-M as a real time analysis tool for process control.

Performance of the GEOSCAN-M at this site demonstrated that analyser accuracies were similar to those achieved between laboratories. This has significantly contributed to the acceptance of the PGNAA technology to minerals applications.

**Minerals Plant (moisture analysis example)**

This example demonstrates the value of information sourced from a microwave moisture analyser. Real time moisture analysis allowed true variation in moisture content to be tracked and further investigation identified some causes for the variations.

This site mines and processes iron ore. Ore was sampled routinely from the conveyor once every one to three hours and moisture analysis performed in the site laboratory. Although water addition was controlled on the basis of the results it generally resulted in product that was (typically) too wet or (occasionally) too dry.

Installation of a TBM200 series microwave moisture monitor provided a new level of detail in moisture content. The site became aware that moisture content was highly variable and that some cyclic trends were present. Haulage of ore by trucks to the plant appeared to contribute to this cyclic variation in addition to the processing operations themselves.

When comparing real time data with laboratory data, some significant excursions were identified which the sampling had not detected. Many of the longer term excursions were at higher moisture levels. These occurred over one to two hours while short term cycles occurred every 20 to 30 minutes. Both of these trends are evident in Figure 8. Laboratory results (average and range shown by the white horizontal lines) indicate that average moistures correspond to the moisture analyser data but variability is much lower than in real time analysis.

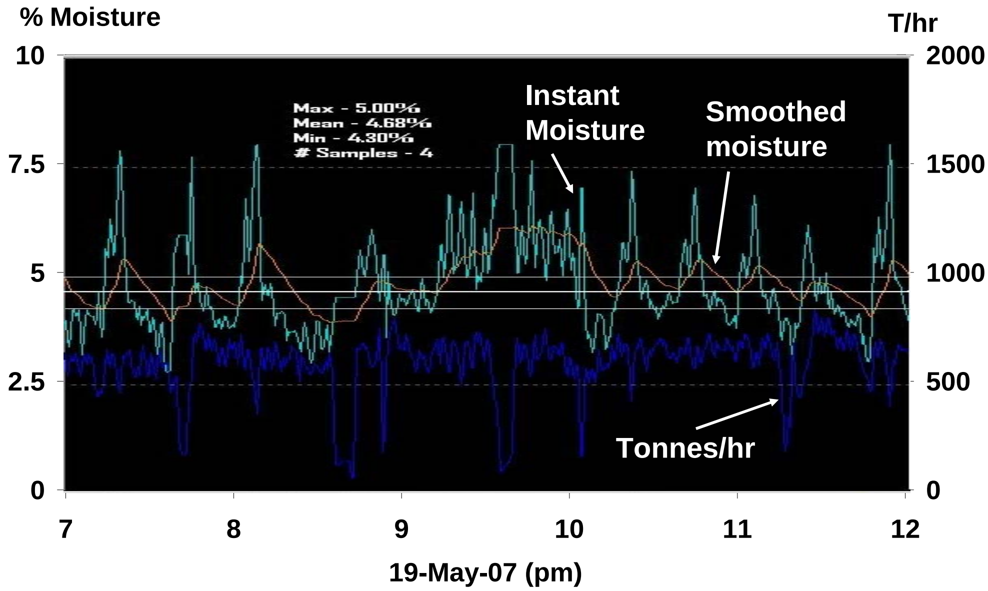


Figure 8. Moisture analysis covering a five hour period. Instantaneous and smoothed moisture results indicate both short term cyclic variations as well as some longer term excursions. There were four manual samples taken for laboratory analysis during the 5 hour period. These didn't detect the hour between approximately 9pm and 10pm where the moisture exceeded 6%.

Installation of the moisture analyser allowed trends to be recognised that were not evident from sampling. Causes were identified and are being managed pro-actively. This has enabled the site to significantly improve moisture management and produce more consistent product.

## SUMMARY

Real time, on-conveyor analysers have greatly improved process control in the coal, power, cement and minerals industries. Analysers can provide major benefits in any industry where material variability is significant and where the variability impacts on process performance. Real time analysis provides not only a means to monitor variability but also to reduce it through bulk sorting and blending. The results include improved efficiency and performance of subsequent processes, maximised resource utilisation and extended mine life.

Site infrastructure and maintenance resources for sampling and laboratory analysis can be reduced and process control improved with confidence in non contact technologies that can be managed remotely. These technologies do not totally replace laboratories, but enhance process control by providing real time analysis for improved responsiveness to material variability.

Many of the difficulties in representative sampling, such as coarse material flows, can be overcome through continuous whole stream analysis. These technologies have proven effective in many applications additional to those covered in this paper, including measurement of mine output quality, stockpiles and loaded shipments. Real time results allows feedback and feed forward of material analyses allowing multiple processes to be optimised concurrently.

The proposed industry focus on metal accounting and grade control through the AMIRA International *P754 Metal Accounting Code of Practice and Guidelines* will further highlight the need to understand and reduce sampling errors. Scantech's analysers can be used effectively to enhance process control and reduce product variability.

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