# CONDITION MONITORING
# for CONVEYORS

## A TOOL for INCREASED PRODUCTIVITY

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## SYNOPSIS

A stoppage in the conveyor transport system means no production in most mining applications. Whether the stoppage is due to a minor problem or a major problem, the effect is the same.

In the coal industry with conveyors carrying between 1,000 and 3,500 tonnes per hour, losses of revenue between $600 and $1,800 Australian dollars per minute can be expected while a conveyor is not operating.

This paper looks at the failure modes in conveyor systems that can lead to lost production. It investigates how various types of electronic monitoring are quickly identifying problems and even predicting problems before they occur. It looks at how a monitoring system should be integrated into the over-all maintenance plan of the mine and how best to allow management to view this information.

The paper provides examples of current systems in use throughout Australia and the equipment and techniques employed to provide the monitoring. Personnel training requirements are covered. The practical experience of Engineers involved in this area, provide the "do's and don'ts" of conveyor monitoring.

Finally methods for determining the success of a monitoring system are discussed and some more unusual side benefits that Management and Engineers have found, may provoke your imagination.

## WHAT IS INFORMATION TECHNOLOGY?

Information technology, by definition, is technology that not only provides the functions of semi-automatic or fully automatic control, but also *informates* or provides information about the process it is performing in both real time and statistical formats. This information is used by shop floor workers, designers and management to quickly identify problems and better monitor the process they are using to produce goods.

In the mining industry information technology has been introduced in various forms from simple mine monitoring systems to full blown SCADA systems. (SCADA is an acronym for Supervisory, Control And Data Acquisition system). A carefully planned and installed monitoring system may not only assist in identifying every day operational problems (such as belt slip or delivery chute blockages), but will also assist in predicting long term wear problems (such as bearing failures.)

## A TOOL FOR INCREASING PRODUCTIVITY

Changes to management reporting of plant availability in coal mines, have highlighted the losses incurred with un-programmed down-time. Management in Australian coal mines have begun to provide bonuses to equipment suppliers for high plant availability and penalties for excessive down-time years after the equipment is installed. High capital investment in large underground longwall mines, requires high utilisation for a return. This has meant that suppliers have been forced to look at long term reliability in system design with an extended operating life for the equipment in mind. It has also meant that feedback systems have been developed to monitor the condition of the equipment throughout its proposed life.

Predicting failures and early detection allows programmed maintenance, and prevents a small failure from turning into a large catastrophe.

## WHY MONITOR A CONVEYOR SYSTEM

Management are unlikely to introduce new technology unless they believe it can provide a saving in operating costs or improve safety which in the long term lowers operating costs. Large amounts of money have been invested in longwall technology in the Australian mining industry. Long wall mining techniques, although expensive to purchase and set up, have the best potential to produce coal cheaply enough to be competitive.

In new mines the conveying systems are designed to cope with the large tonnages that the longwall miner can produce (up to 3,500 tonne per hour), however in older mines the conveyor system is usually upgraded to handle the extra tonnage and more often than not, falls short on its ability to carry the extra load. Without a reliable belt transport system the potential of the longwall miner cannot be realised. Down time on conveyors is down time for the mine.

Specific advantages of conveyor monitoring include:

1) Instant identification of the reason for a belt stopping, which reduces fault finding time.

2) Ability to notify maintenance personnel of the problem before they travel to the breakdown and therefore assist them to carry the correct equipment to rectify the fault. Eg. an earth leakage fault would require the use of a megger.

3) A permanent record of breakdowns is available that allows for better analysis of down time and therefore better utilisation of limited resources.

4) Analysis of long term breakdown data will allow for effective preventative maintenance schedules to be planned and implemented.

5) Trending of bearing temperatures, CO, $CH_4$ and air flows can prevent potential dangerous conditions such as fires or explosive atmospheres.

## PLANNING A CONVEYING MONITORING SYSTEM

1) **Define desired operating parameters of process and desired production levels, equipment availability.** As part of the overall mine plan the peak demand for the conveyor system has to be determined, which may be much greater than the typical production level. For conveyors, consideration has to be given to power requirements for starting the

conveyor fully loaded. In the past this has been underestimated, with delays due to overloads, belt slip etc. Many hours have been lost when it has been necessary to shovel coal from a conveyor in order to start it. Equipment availability percentage should be nominated as part of the initial specification for the conveyor system. Without nominating this factor it is difficult to return to the supplier later on and request improvement in the conveyor performance. In order to meet the availability requirements, the supplier may well incorporate a monitoring system to provide feedback on conveyor performance.

2) **Staffing levels.** It is important to nominate the required number of people with the correct skills to ensure that the system is maintained. This may require extensive training and skill upgrades by the supplier for the mine personnel. It is important that the mine staff be trained to use the analysis equipment and fault finding tools incorporated in the conveyor design. Failure to pay attention to the above can result in the installation of a fault finding system which creates more problems than it solves. Part of this requirement may be off-site access by the supplier through modem and an underground communication network. If an unusual problem occurs it is usually much quicker and cheaper to have the supplier identify it electronically than to have them travel to the site.

3) **Engineering failure & effects modes analysis.** As part of any complete conveyor system design, a failure & effects modes analysis should be included. This process helps identify possible failures that can occur and help predict how the system will react to these failures. It also shows weaknesses where extra effort must be put into the design to ensure that these failures do not cause problems in both safety and production downtime. It is important to have as many people involved in the failure & effects modes analysis as possible. The team should include production workers, maintenance tradesmen, maintenance engineers and system designers. If proprietary equipment is used in the design, then experienced representatives from these companies should be involved to define how their equipment reacts under failure.

4) **Ongoing Training.** It is important to follow up all the factors above with ongoing training and personnel skill development. It is easy to ensure initial training occurs but with staff rotations and personnel changes it is important to ensure that all new staff are brought up to the required skill levels as an ongoing process. A well designed system will only fail on an irregular basis. It may be many months or years before problems occur. Personnel may forget their training over such long time spans, so it is important to run short refresher courses.

## CONVEYOR FAILURE MODES AND HOW TO DETECT THEM EARLY

### Pulley failures

Bearing collapses of large pulleys under tension can cause considerable damage to the drive head or delivery jib structure. Heated bearings may also start fires, fueled by dust, grease or paint. Down time for repair may range from several shifts to several weeks, depending on the availability of spares and labour. A worst case scenario might require the removal of structure to the surface for repair and then re-installation underground. Occupational Health and Safety in coal mines may force closures as integrated protection systems are installed. This action has historically occurred after a dangerous or fatal incident. A failure modes analysis may have identified the problem as a possible danger.

There are two methods used for early detection of bearing failures in pulleys. The most common and easiest method to implement is temperature. A more sophisticated method is vibration or frequency analysis. When bearing temperatures exceed seventy degrees Celsius, grease begins to thin and may run out. If the bearing reaches ninety degrees Celsius, then imminent failure is likely. Vibration analysis requires more sophisticated equipment as it is only certain frequencies that depict problems with a bearing. However any excessive vibration detected by accelerometers will provide some early protection.

### Idler failures

Although idlers are not as critical as pulleys, poorly maintained idlers may provide a fire risk. It is normal practice for conveyors to be inspected on a regular basis by deputies who visually check and listen for idler problems. Recently, advances have been made with infrared non-contact scanners that provide an improved tool for early detection of bearing failure in idlers. These are approved for underground use in Australia and allow the operator to measure the surface temperature of a rotating bearing from a safe distance. With main gate conveyors that have their idlers removed as the longwall advances, ultrasonic inspection of bearings has proven to reduce idler failures during the life of the block.

### Electric motor failures

Motors normally fail through excessive temperature or bearing collapse. Modern motor protection relays, thermally model the inside temperature of motor windings and provide improved protection for the motor. It has been common practice for many years to incorporate temperature sensors into the windings of motors to provide additional over temperature protection. Lug type temperature sensors mounted on the outside cases of bearings will also prevent motor damage from collapsed bearings.

### Gear box failures

There are two methods used for early detection of gear box failures. The most common and easiest method to implement is temperature. A more sophisticated method is vibration or frequency analysis. As oil is used as both a lubricant and a coolant, bearing and gear failure will increase the temperature of the oil.

### Belting damage

Conveyor belting is an expensive component of a conveyor installation. It is typically one third the cost of the complete installation for nylon and polyester belting and higher for steel cored. It makes good economic sense to keep it in good condition.

#### Belt Rip

Belting may be longitudinally split by various methods. It has always been a difficult problem to detect. Many Engineers believe that prevention is superior to cure in this case and take elaborate precautions to limit the possibility of any item causing belt rip. The following are examples of causes of belt rip.

- A roof bolt losing its bonding and dropping down onto a belt. This is more likely a problem where there is little clearance between belt and roof.
- Shale being caught in transfer points and slicing the belting.
- Pit props being caught at transfer points and slicing the belting.
- Roof bolts being caught at transfer points and slicing the belting.

Prevention techniques include :-

- Education of all mine personnel to ensure that only coal travels on conveyors.
- Installation of magnets to remove tramp metal from conveyors.
- Ensure that crushers at the end of the longwall face chain, break the coal and shale into small enough pieces so that they don't get caught in transfer points.
- Transfer point design that does not trap long items that can cause belt rip.
- Coarse sloped grates at transfer points to remove large objects. (These need height and may not be suitable for all underground use.)

However if all the above precautions fail, then the following methods have been developed that will detect a ripped belt.

Figure eight loops of copper wire can be molded into the belting at manufacture time. Inductively exciting the loop with one transducer and then reading with another will ensure that the loop is un-broken. A microprocessor based controller monitors each loop in the conveyor and detects when one is broken. A broken wire indicates a rip in the belt. These units are expensive and normally only used on steel cored belts.

Belt width measurement with the use of ultrasonic transducers will indicate belt rip. In principle, if the belt has a longitudinal tear the two pieces will either pull apart and make the belt wider or overlap and make the belt narrower. Several units have been developed. One unit measures the distance from the edge of the belt. Another unit uses a string of sensors across the belt. If narrower pieces of belting are spliced into the overall conveyor, then some additional smarts have to be introduced to track that narrower piece of belting.

**Clip & Splice Failure**

Currently there are no automatic detection methods for clip and splice failures. Dating of clip joints by carving the date into belting adjacent to the clip and regular belt inspections, are methods currently employed. Broken belt detection by monitoring the movement in the loop takeup can reduce down time if a clip or splice should fail. Normally the only way of stopping a conveyor that has a broken belt, is when the loop takeup full limit trips, or the conveyor stops on belt slip. The belting may be pulled apart by several hundred meters before a trip occurs. This can cause a considerable delay and may require clipping in an additional piece of belting that can be driven to a splicing table and removed later. *Loop movement* broken belt detection can reduce the pull apart to 20 meters.

**Online estimating of maximum tension in the conveyor.**

By measuring conveyor speed, motor power and loop tension, the maximum tension in the conveyor can be continually calculated in a PLC. The tension signal can be graphed in real time and provides a valuable tool in analysing conveyor performance if there are any problems. This is particularly important during conveyor starts and when tripper drives are used.

**Edge damage - bad tracking.**

Edge damage is caused when the belt rubs against structure, boot ends or may even be folded over in splicing tables and loops. Edge damage can restrict the amount of coal on a conveyor due to less width and can cause spillage. It will also allow water into the weave, causing rotting and reducing the life of the belting. Bad tracking also places extra stress on clip joints and splices.

Careful installation and alignment is the best insurance against tracking problems. Laser alignment installation is now common in Australian underground coal mines. The alignment of clip joints and splices is also important. Tracking limits at various places provide insurance against a belt tracking off and damaging the edge of the belt. Once the edge of the belt is damaged it is difficult to pick the line of the belt and therefore square off the joints. This exacerbates the tracking problem further.

Many mines use roof suspended conveyors where floor heave can cause conveyor alignment problems. This however, makes controlling the conveyor during starting, a little more difficult. There is less structural inertia to dampen out tension waves.

**Carcass damage**

Chute design that assists material to flow onto the belt at transfer points, instead of dropping onto the belt will reduce carcass damage. A carefully aligned conveyor will also prevent the need for idler roller tracking adjustments. These provide a scrubbing action on the clean side of the belting.

### Belt slip

Belt slip protection is regulatory in all Australian Coal mines due to the danger of fire. Any slip of the drive pulleys against the belting will damage the belting, as well as the pulley lagging. Past belt slip protection methods involved under speed detection after the startup period. With modern larger conveyors and starting techniques, this is considered insufficient. Slip is now calculated in the PLC controller and is the difference in speed of the driven pulleys and the belt speed. It is measured in meters per second of slip and is continuously enabled. This provides the fastest response to belt slip and therefore minimises the damage it causes.

## Tensioning equipment

### Gravity tower

Gravity towers are normally low maintenance devices, however monitoring of the rate and amount of movement during conveyor operation via a position encoder on a sheaf is useful information for analysing conveyor performance. This will provide the amount of stretch from no-load to full load. It will also indicate the amount of stretch during the start and any oscillations in motion indicate tension waves transversing the conveyor. The lack of motion during a start may indicate a jammed mechanism.

### Loop takeup equipment (underground applications)

The following fault conditions are normally monitored and provide trips in a loop take-up and winch control system :-

- Winch Motor Fault
- Coupling Fault
- Brake Fault - protection for the conveyor should the winch not be live or unable to hold tension when stopped.
- Over Speed - Protection for the winch should a large tension spike over speed it.
- Over Tension - shut down to protect from control system failure or excessive tension spikes in the conveyor.
- Slack Rope - prevents damage from no tension control should the carriage jam or the rope brake.
- Tracking Limit Fault - prevents edge damage to belting.
- Loop Full, Loop Empty - protection to prevent the loop from operating outside it’s limits.
- Carriage position - allows for programmed input and output of belt on development and longwall conveyors.
- Broken Belt - quick shutdown should excessive haul in of the loop be detected.

## DETECTION METHODS

### Temperature monitoring

#### Digital types

**PTC thermistors -**

Are units designed to operate at a knee temperature point. There is a sudden increase in resistance as the knee temperature is reached. They are small in size and cost and have been traditionally used in motor windings. They require an electronic interface into the rest of the control circuit.

**Solid state temperature switches**

Have high resistance (100Kohms) until their temperature reaches operating point at which their resistance drops to around 100 ohms.

**Bi-metallic switches**

Are switches that open at a particular temperature. They are low cost and can be used to trip control circuitry in case of over heating. They typically operate at temperatures of $70^{o}$ and $90^{o}$ C.

#### Analog types

**NTC thermistors**

Negative temperature coefficient thermistors produce a linear relationship between temperature and resistance. Electronic relays are required to translate the resistance into a temperature trip set point or analog signal.

**Solid state**

Solid state temperature sensors provide an output current or voltage proportional to temperature. They are accurate to 1 degree Celsius over a range of 0 to 150 degrees. They offer the advantage of small size and may be fitted into places that other analog transducers can't fit.

**RTDs - Resistive thermal devices.**

PT100s are an industry standard wire wound resistor of platinum, with a fixed ratio of resistance to temperature. They are 100 ohms at zero degrees and increase in resistance at 0.385 ohms per degree Celsius. A fixed current is passed through them and the voltage across them is measured. An additional sensing wire is used to compensate for any voltage drop in external wiring. Many motor protection relays come equipped with direct connection for

PT100s wound into the motor windings. These temperatures may be accessed via a serial interface to a PLC and then on to the SCADA system.

### Field multiplexers

When a large number of field temperatures are being monitored, it may be advisable to use multiplexers or data concentrators, as there are sometimes calls to cut down on installation and hardware costs. These units update data in less than two seconds and are more than adequate to monitor temperature which does not change quickly.

### Analog versus digital monitoring

For protection, digital temperature trips are often used. However to allow for analysis of a system's performance, it is better to provide graphs and trends of actual values. Normal operating parameters can then be determined. In some cases external conditions may keep some bearings much cooler than others. The cooler units may require their warning points to be lowered. For preventative maintenance it is important to see a temperature of a bearing trending upward over a period. When a temperature trip has occurred it is too late to prevent the trip with some programmed maintenance.

### Set point trips

Most SCADA systems allow for warnings and alarm conditions which will indicate when a trip has occurred. For a bearing, a warning may be given at $70^{o}$ C, an alarm at $80^{o}$ C and the conveyor may be tripped when the bearing reaches $90^{o}$ C. The PLC would provide the trip at $90^{o}$ C. The SCADA front end would provide the warnings and alarms.

### Rate of change alarms

Occur when a temperature that is normally slow to rise increases suddenly. It is useful on a variety of applications including gearbox oil temperature monitoring. By trending a temperature for a period, the normal fluctuations of a gearbox may be determined. A rate of change alarm now may be set up to indicate any rises or falls of temperature outside the normal. This provides very early indication of problems, and highlights to maintenance personnel that this particular device needs closer attention.

## Vibration Analysis

Vibration analysis is a specialised field that accurately predicts the condition of mechanical devices. It is not simply a technique that looks for too much vibration, but looks for increases in particular frequencies. These frequencies are normally analysed by computer software and a condition report issued.

**Excessive Vibration**

Simple accelerometers depict too much vibration in equipment. They are often used on equipment such as compressors. They will not detect what is wrong, but will indicate trouble before a mechanical collapse.

**Frequency Signatures**

The first step in this analysis is to take a frequency signature of a piece of equipment that has been installed. This is done using analysing equipment and then down loading the results to a computer. The initial signature will also determine if a device has been assembled correctly. At regular intervals a new frequency signature is taken and compared to the old. If they are similar then the device is still in good condition. If there is a difference then the wear areas can be determined based on which frequency bands have changed. This is a complex area and would warrant a full paper in itself. However gearbox manufactures in Australia have significantly reduced their first year warranty claims by employing this technology.

**Position detection**

Is usually achieved through a quadrature signal being fed from a rotary device. It may be a fine manufactured device or a coarse unit created from proximity detectors and blocks on the side of a winch drum. The PLC can use a quadrature encoder card for fine resolution, or some software to provide a count that relates to position for the proximity detectors. More accurate measurement of small movements, such as brake wear, can be detected with LVDTs.

**Explosive atmosphere considerations**

One problem that faces the coal mining industry is monitoring in methane atmospheres. Although there are many techniques for safety with methane atmospheres, the most appropriate for condition monitoring is **Intrinsic Safety**. With this technique, the energy in the field in limited to less than 300 joules. There are many modern transducers that aren’t allowed to be used underground. The extensive testing and development necessary for Intrinsically Safe products, means that the latest technology takes a little time before it is available for use underground.

**Future Monitoring Developments.**

The Australian Government research organisation, C.S.I.R.O., in conjunction with BHP, has developed a vision system that is to be used for the sizing of rock traveling in excess of 4 m/s. This technology has now been commercialised by Adept Engineering in Western Australia. Investigations are currently under way in the use of this technology for clip inspection, belt rip detection and large foreign object detection for use in underground coal mines.

Newcastle University are investigating the use of monitoring devices that are molded into the belting and store the temperature of idlers as they pass. At the end of the travel they download their information for analysis.

Companies in Australia are currently developing simple frequency analysis devices that will be low cost enough to use on all major bearings.

## OTHER PRODUCTION LOSSES

### Signal line / Pull switches

Monitoring of which switch along the conveyor has caused a stoppage can save considerable down time. Often when work is carried over between shifts, it is not known which safety switches were used to turn the conveyor off. A signal line system that indicates to the control room, exactly which switches are off can save a person having to walk the conveyor checking each switch. A simple phone call to the drive head or control room can prevent considerable production loss.

### Remote isolation

New regulations and electronic developments, now allow remote isolation from any point on the conveyor. In the past when structure on a maingate or development belt was removed or added, it has been safety policy for mining personnel to be transported to the drivehead and place their personal danger tag on the main conveyor isolator. With shortages of transport, often delays are encountered, or personnel take short-cuts and do not isolate correctly.

## ACCESSING THE INFORMATION

### Simple two wire systems

The earliest systems installed in Australia consisted of the Dupline two-wire system and mimic panels on the surface. The mimic indicated if the conveyor was running and displayed up to another seven groups of faults. Up to 16 conveyors could be monitored this way. This system was low cost and easily retrofitted to conveyor starter panels. Transmission distances up to 10 kM were achieved. Dupline and other two wire products such as Ringline, are still used to retrieve information along a conveyor, but typically this local data is correlated in the drive head PLC and transferred to the SCADA via a PLC network. These two wire powered, intrinsically safe systems are best suited to lanyard switch monitoring and remote isolation applications. They are also useful for retrieving data on small I/O count items such as compressor and pump stations. The data may then be interfaced into a larger PLC at a drive head.

### Other Specialised Products

Various other specialised products were developed and trialled. An early attempt to use the Honeywell W7000 energy management system provided some insight into what might be achieved, but proved too slow and difficult to maintain and is no longer in use. Several other mining companies developed specialised products, but with a small market they proved expensive and could not keep up with the pace of technological change. Very few are still in use, with a PLC at every drive head in the majority of mines.

**PLC networks**

The most commonly used PLC network in Australia is Allen Bradley. Both the Series 5 and the 500 Series PLCs are used. The DH+ network links all PLCs to a Personal Computer (PC) on the surface running a SCADA package. This network also allows the down loading of program changes and panel view updates. It is normal to have several networks installed. The longwall is a separate network, the conveyors another and the surface a third network. This is done, so that should a failure occur in one network, the others are un-effected. A few mines are now installing fibre optic sections instead of complete cable networks.

Other PLCs used at various under ground mines are :-

- Modicon Gould with a Mod Bus network (RS485).
- Square D with a RS485 Network.
- Omron with an RS485 network.
- Siemens (TI545).
- GE Fanuc with a fibre optic ethernet network.

Selection of which PLC to use is a personal choice, but many suppliers have developed software algorithms for particular PLCs and to transfer to another brand is not always a simple task. Boolean ladder logic transfers easily, but analog capabilities and communication networks vary between brands. Extra expense may be incurred if software is to be re-written.

**SCADA**

A SCADA system is normally a combination of products integrated to produce an overall package. Typically in Australia, PLC based networks control the conveyor system and collect the data. This information is then accessed via an interface into a PC network on the larger systems. Proprietary packages such as Citect, Genesis, Fix Dmacs, WinView, Control View, and Macro View are then used to display and log the data. Nearly all are now Windows based systems that offer advanced facilities in visual displays, alarming and logging.

Selection of the package to display the system is a personal choice and most modern packages will perform the task effectively. The following criterion should be considered when evaluating which product to use:-

- Local support. The level and the expertise that is available to support the package. These programs are sophisticated and will take some time to learn. It is important to have phone access to experts in the package when problems arise. The support should also be able to train mining personnel in its use.
- Ease of configuration. In a mine where systems are continually changing, it is critical that the package be simple to reconfigure. The SCADA system will need to be updated as the mine plan changes. If it is not kept up to date, it will not serve it’s purpose. In the larger coal mines in Australia, this task is a full time job for an employee.

- Software Update Path. It is important to have some indication from the supplier that there is a planned update path that does not require a re-write of your SCADA system. Each upgrade needs to be backwards compatible.
- Proven system performance. The monitoring system should be ‘Real Time’. One problem in the past, has been the speed at which data can be retrieved. Real time dictates that all data is updated every two seconds. Special consideration must be given to data format and throughput. This requires planning and careful design by personnel who are experienced and proficient in this field. Data blocking in PLC programming is important to maximise throughput rate.

## TIPS for a SUCCESSFUL INSTALLATION

In her book "The Age of the Smart Machine" Shoshana Zuboff demonstrates the importance of user understanding and ownership of new technologies before they are able to be effectively incorporated in an organisation. No matter how effective or desirable the technology, its acceptance and therefore effective use, is dependent upon the workers who will be using it. If the workers have reason to believe they have not been informed about or adequately trained to operate the technology or do not fully understand it's function, not only will they not be able to properly use the equipment, they may go to some length to block the proper operation of the machinery. At best they may never go beyond a superficial user level and therefore the company will not obtain any of the intended benefits of the technology.

Zuboff looks at different methods of introducing new technologies. She documents one organisation which believed that because they had decided to introduce technology, the workers, if given minimum training, would see the benefits and adopt the new technology. This proved to be quite wrong as the workers were used to operating transparent machines, that is they could always see what was happening, and did not have to depend on computer outputs to tell them what was going on. They continued to monitor equipment their own way, even though their judgment could not be as accurate as it used to be, and used the computer only to check their own assumptions, with the result that production was actually slowed by the new technology. Another organisation gave maximum training to all employees, regardless of whether they really needed such in depth information, with the result that these employees spent more time being challenged by what the technologies could do than in actually carrying out their work tasks. In this situation they lost direction and did not improve output as a result of the new technology. A third organisation integrated new technology as part of a whole workplace program with workers informed about each new process and trained to the level required by each piece of machinery. Needless to say the third organisation recorded maximum benefits from new technology whilst the other two organisations were still trying to work out what went wrong.

Some important considerations when introducing new technology include:

- Always install condition monitoring as part of an over-all strategy for improving productivity.
- Always ensure that staff are adequately trained to use the monitoring effectively.
- Never install technology just because it looks impressive. It must have a defined use within your organisation. Personnel must be aware of this and utilise it to it's fullest extent.
- Monitoring equipment should be selected for it's proven reliability or it may cause more down time than it's intended to eliminate.
- Always consider an upgrade path with the initial installation. Experience has shown that reliable condition monitoring systems are always extended when management see how successful they are.
- Don't be fooled into believing that monitoring can be a background task for a PC. It will require the full attention of a PC and more.
- Keep a check on the systems performance. Is it providing you with the information you require? Are you showing improvements in down-time? Do you have a better insight into the mine's performance? If not, what has to be changed to achieve this?

## SOME UNUSUAL BENEFITS

A graph of the maximum tension on the maingate conveyor gives an excellent indication of the coal producing performance of the longwall. By integrating the load curve above no load running conditions, you have a visual indication of production minute by minute. This can be logged and kept as a complete record of production.

An Engineer at Metropolitan Colliery was keen to reduce his electricity bill. The mine was on a maximum demand tariff, and he considered load shedding as a means of reducing his electricity cost. The first step was to monitor and graph his underground feeder power consumption. This he did for a period of several weeks to gain a profile of power consumption. He noticed the consumption in his panels consisted of a surge of power while the miner was cutting and then a drop, while the shuttle car took the load to the conveyor. He also noticed there was a drop off when the miners went for crib. He could tell how long they took for each crib and how many shuttle cars they had cut. He then began to compare the number of shuttle cars cut by virtue of power consumption, to the number reported by the deputies. One in particular always used to take a little longer for crib and add a couple of extra cars in his report. The engineer began asking how many cars were cut as the deputy emerged from the mine and had great delight in correcting the deputy if he had fudged a few. To this day the deputy, does not know how the engineer has caught him out.

## CONCLUSION

The new Shell North Moranbah underground mine is currently being developed. The SCADA system will monitor 307 alarms, 159 digital points, 58 logged integers and 235 display integers on the drift conveyor alone. This data will be able to be accessed from the surface control room, engineering and management offices, or any drive head in the mine.

Every time I have been involved in a monitoring installation, the feedback from Engineers and Management has always been positive. All systems have been extended when the initial system has proven its cost savings. Improvements in down time losses, easily fund the expansions. Finger tip information, improves peoples understanding of their belt system and allows them to quickly identify and rectify problems. High conveyor availability is now the expected on all new installations. This has only been made possible with improving condition monitoring.

## REFERENCES

Shoshana Zuboff, *In The Age Of The Smart Machine* (USA, Basic Books, 1988)

Dr Greg Eaton, *Using Outside Industry Standards Systems For Mine Monitoring* (BHP internal document and presentation paper, 1993)

Moranbah North - Process Control Systems team. - Representatives from CI Technologies Pty Ltd, Nulec Pty Ltd and Shell Capcoal.

Peter Clarke - Adept Engineering - Manager.

Greg Potter - Continental Control Systems - Engineering Manager.