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CONTENTS

Innovations in seeking to provide an incident & injury free workplace during construction of the Hail Creek Coal Project

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Synopsis

Hatch Associates and Hail Creek Coal developed a Safety Management System for the Hail Creek Coal Project that delivered a step change in site safety management. It was built around hazard identification, risk assessment and risk minimisation or elimination, for every task being undertaken. Hatch was responsible for the implementation of the systems, and to verify compliance and measure effectiveness.

Whilst encountering initial doubt and resistance, it was a proven success with the Project achieving, at the first attempt, an NSCA 5 Star rating for the safety management system and application. The railway portion of the project was also awarded the Queensland Master Contractors' Association 2002 Safety Award.

The impact of the safety program has had a substantial effect on individuals and contractor organisations and shown that leadership can and must change the approach to safety management in the future. In many areas, the results should lift the current construction industry standards.

Description of the Program

Hatch was appointed as the Project Management Organisation for the Hail Creek Project in September 2001. The client was Pacific Coal, a wholly owned subsidiary of Rio Tinto that operates three other coal mines in Queensland.

One of the key criteria for award of the Project to Hatch was the demonstration given of our ability, preparedness and willingness to manage safety on the site and to meet or exceed Pacific Coal and Rio Tinto's safety standards. It was the first major construction project, carried out on a coal mine lease in Queensland, since the introduction of the new Queensland Coal Mining Safety and Health Act 1999 (the Act) and Coal Mining Safety and Health Regulation 2001 (the Regulation). Therefore, the Safety Management System (SMS) used on the project, had to be assembled to incorporate the features of the Act and Regulation.

The cornerstone of the SMS and what drove the way it was administered was the Vision. This was a joint development between the Hatch and Hail Creek team members and stated our unconditional commitment to providing a safe and healthy workplace for all employees.

From this vision, we established a Safety and Health Policy. The policy contained the vision and set out our stands and principles.

We were strongly influenced by the commitment and passion of the Hail Creek managers. They left us in no doubt as to the level of performance and dedication they required. Together, we believed the following to be fact:

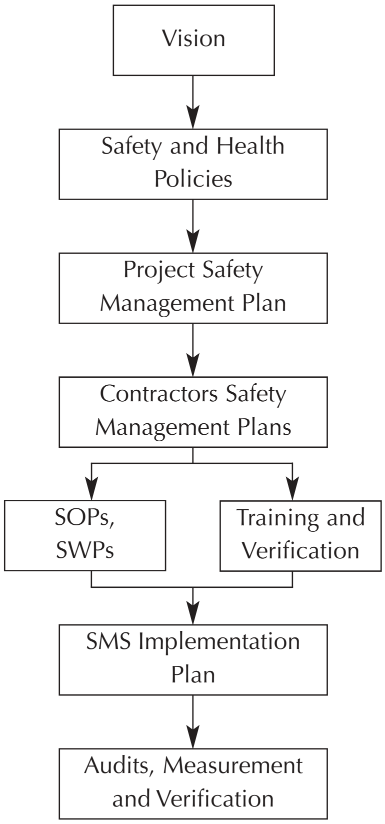
- Acceptance of the principle that all incidents and injuries can and must be prevented
- Leaders and Managers at all levels are responsible for workplace safety
- Safety should have at least equal status along with other primary business objectives, such as time and cost
- The need to provide properly engineered and safe systems of work
- Unsafe acts and conditions, which may result in incidents, must be eliminated
- It is necessary to have all employees accept their responsibility to work safely and to understand that it is to their advantage, as well as to their Company, that they do so
- Incident prevention is good business. A safe project is usually an efficient and cost effective project
- Nobody wants to hurt themselves or other people.

With these beliefs and values, we set out to implement a safety management system that incorporated all of our undertakings to Pacific Coal and each other, the provisions of the new legislation and Hatch's corporate commitment.

Hatch took with it into the project a basic safety management system built around Hatch's eleven key elements of safety management:

- Leadership and commitment
- Performance measurement and reporting
- Involvement, communication and motivation
- Contractor alignment
- Training and competency
- Hazard and risk management
- Occupational health and hygiene
- Safe systems of work
- Incident reporting
- Site management and
- The environment.

Using this format, we produced a safety management system that set out our process to manage safety on the Project. A road map shows the system in its logical hierarchy:



So far, what I have described we were doing and the way we were approaching it would be fairly standard procedure for a new project, just starting up. The BIG difference and what set us apart on the Hail Creek Project, was that WE ACTUALLY DID EVERYTHING THAT WE SAID WE WERE GOING TO DO!!!

Implementation

The Act came into force in March 2001. Operating companies had had approximately two years (since 1999 when the legislation was passed) to implement the provisions. Hatch was appointed the Coal Mine Operator for the Project and provided the Site Senior Executive in September 2001. This meant that the Project team had less than six months, to get a compliant SMS in place before major construction work started on site.

The first priority was to establish the Safety Management Plan. This plan detailed the Project's safety objectives and incorporated over sixty Standard Operating Procedures, dealing with various activities and conditions, a Principal Hazard Management Plan for activities likely to cause multiple fatalities, an Emergency Response Plan, Personal Safety Action Plans that detail actions to be undertaken by staff members and responsible persons and supporting training programs. It was a significant body of work and was a joint effort by Hatch and Hail Creek safety professionals, with support from consultants. It set the tone for our performance and that of the contractors.

The construction industry differs from mining in many respects. Hatch and the contractors, had to carry out construction work under an Act that was clearly focussed on safety in and around a coal mine. Whilst the safety message was valid, the provisions and methods of implementing the Act were new to most contractors. Traditionally, construction safety is less prescriptive and the discipline less rigorous, than the standards expected on a mine. The construction workers are emerging from an era, where safety thinking believed that it wouldn't happen to them and that they just had to be careful. There was no fundamental belief that safety was good for your health and long-term well being! This lack of having safety as a core value in the workforce was the principle obstacle we had to overcome. Durations on site ranged from days to months and the challenge was to start to change behaviours in such a short time frame. Many construction workers would not have heard of risk assessments, or had not come to the realisation that safety was all about planning rather than trusting to luck. They'd been doing this for 20 years and never been hurt!

To be successful, we had to make our expectations known and to gain commitment from the contractor companies to make it happen. We therefore identified some key requirements in the process of allocating work.

- *Careful selection of contractors.* Prospective tenderers had to show that they shared the necessary values, attitudes and behaviours that could achieve our desired results. A detailed prequalification questionnaire was sent to prospective tenderers.

- *Careful selection of Project Managers.* As discussed later, leadership was a vital component to success. The contract's Project managers were therefore key people in changing workforce behaviours. Each prospective Project Manager was interviewed and required to submit and meet, a personal safety action plan that was regularly reviewed for compliance.

- *Careful selection of people.* A detailed recruitment program verified compliance with the specific project and legislative requirements. We established a labour coordination office in Mackay to review job applicants and assist contractors with the mobilisation process.

- *Leadership.* We believed that the most important element of getting workforce safety behaviours to meet our expectations was through all line managers and supervisors demonstrating clear, unambiguous, consistent leadership as to what was an acceptable level of performance. This leadership was shown from the Hail Creek and Hatch senior Manager down.

  Anyone in charge of personnel was deemed to be in a leadership position and had to go through a two and a half day leadership workshop, with follow up sessions on site. For many supervisors and leading hands, this was their first exposure to understanding and acquiring leadership skills.

- A *"no compromise"* approach was adopted. We demanded compliance with the Site Rules, Contractors' Golden Rules and Procedures as laid down.

  In the event that changes were identified, or Rules needed to be modified for particular issues, these were handled through a risk assessment and the application of the formal change management process.

- *Full involvement of the Contractors'* Project Managers, managers and supervisors in the safety management process.

The site personnel were team oriented and all matters that affected the workforce were discussed via the Safety Steering Committee and Safety Implementation Committee. This involved all the contractors.

- *Contractor Safety Management plans (SMP).* These were prepared by the Contractor and either written by them or modelled using Hatch's SMS. We made the SMS available to all Contractors on CD-Rom. After submission by the Contractor, their SMPs were audited against a formal audit tool developed to assess compliance. A score of over 90% was necessary before a plan was accepted. Contractors were refused permission to mobilise until their plan had been approved. In particular we were looking for clear evidence of:

    - Ownership
    - Leadership
    - Commitment
    - Responsibility
    - Accountability
    - Verification

  by the contractors in their plans.

- *Safety meetings* were held with the contractors before mobilisation. The first was held in the post tender – pre award period, where Hatch would interview the tenderers' CEO, Site Project Manager and Safety Adviser. The meeting took them in detail through the contract provisions and Hatch's expectations and obtained a commitment, at the highest level, that they were prepared to meet those standards.

  Once they were awarded a contract, we held a further kick-off meeting with them, where we again went over the safety performance requirements on site.

  The outcome from these meetings was that contractors were unable to claim ignorance of what was going to be required at site, or to say that they had not made appropriate allowances in their contract price.

- *Auditing and Inspection.* Within two weeks of a contractor mobilising to site we carried out a mini systems audit against their SMP's. For many contractors this was their first taste of having to implement their SMP's. Within one month, we carried out a field audit and followed up with a second systems audit. Both these audit tools were designed for project start up. As the contract bedded down, Hatch developed another audit tool that had greater depth of interrogation and dug down to ensure the systems were being correctly applied and operating in the field.

  In addition, Hail Creek, Rio Tinto, NSCA and external auditing bodies carried out regular third party auditing.

- *Formal workplace inspections* were carried out on a scheduled basis (at least weekly) in each work area. The inspection team consisted of a representative from Hatch, Hail Creek, the Contractor Project Manager and the area supervisor. This group had the power to stop work or change work methods immediately in the field, without referring back for management approval.

- *Inductions.* An induction was mandatory for all personnel coming to site. This gave details of the Project's expectations and commitment to safety. The Project Manager and a Hail Creek representative opened all site inductions. The Safety Manager delivered job hazard analysis (JHA) training, so hazard assessment and risk reduction skills were covered. Workforce numbers peaked at 900 and in eleven months, almost 2000 people received this induction.

- *Support from Hail Creek Coal.* This was one of the most significant aspects of the Project's success. Hail Creek Management fully supported any initiative that could assist in improving the safety performance. Program and cost considerations were always secondary to the primary goal of providing a safe work place. Throughout the Project, I cannot recall any occasion when Hatch has been denied or questioned on a safety initiative or Hail Creek has failed to support a safety issue that we have proposed or needed. This kind of Client support and commitment bred the confidence necessary to demand people to change their attitudes and behaviours.

Safety Initiatives

A safety management system is ineffective unless it is live and dynamic. This requires leadership and motivation. We found that as soon as leaders and managers lost focus, the level of incidents would rise. We kept things alive and vibrant with a series of Safety initiatives.

- *Pre Start huddles*
  Every work group attended a daily huddle at the start of the shift to discuss safety initiatives undertaken the previous shift; what made it safe or unsafe and what was going to be different about the next shift and how could we improve our collective safety performance.

- *JHA (Job Hazard Analysis)*
  This was the fundamental tool used by everybody on site to identify hazards and assess and mitigate risks. A JHA was completed for every task and reviewed at the start of each shift. If a new person was introduced to the area or a new hazard, or conditions changed, the JHA had to be reviewed and, if it was no longer applicable, it was re done.

- *RESTART program*
  This was an initiative Hatch developed after witnessing a similar program on the Comalco Aluminium Refinery project in Gladstone. It was a formal program that empowered anybody to stop a work group if there was an unsafe act or condition in the area and go through a process of identification, communication and removal. The work crew then signed off on the revised work procedures and re-commenced work.

- *Good Performance Safety Awards*
  These were issued to workforce members who implemented better ways of doing things or showed good initiative and who demonstrated a positive attitude to safety. A laminated certificate accompanied the award. Even though these were 'small' gifts, they carried great kudos.

- *"Getting the Message Across" Program*
  This was a program designed to ensure that sub contractors

mobilising were brought up to speed in the expectations of the Site as quickly as possible. It was a five-week program that commenced before the sub contractor mobilised and continued for the first month on site.

- *"Refocus" Programs*
  From time to time during the project, we would find our attention and concentration wandering. We felt that the safety management was starting to drift. This was often accompanied with a rise in incidents. The Refocus Programs were a chance to regather ourselves and get us back to managing safety in a proactive way.

- *"Safety Stars" Program*
  A program used towards the end of the project to take the high safety achievers from each contract group. These were the people who had impressed their Managers with their excellent safety attitudes and who you would want to work with again. We involved them in workshops and challenged them to use their skills to explore ways to do "it" better and take the skills learnt with them to the next job. This program gave positive recognition amongst their peers, to the people who had shown initiative in safety leadership.

- *Safety Behaviour Observations (SBO).* The construction workforce initially treated this process of assessing work behaviour with suspicion. They tended to feel threatened by being approached by a group of 'heavies'. Over time, these reservations disappeared and a "pick me!" attitude emerged. The discussions became very productive and built a good bridge between workers and management.

- *Sundowners with the Supervisors.* This was a drink after work with the contractor supervisors and Hatch Managers, on a company by company basis. It was an informal discussion to get things out in the open. Once people realised that these were meant to be a positive exchange of views, a lot of ideas and concerns were put up for discussion and corrective actions initiated, often before they became issues.

- *Incident Reporting and Lessons Learnt.* There was a culture on site that allowed people to feel comfortable in reporting incidents. Hatch was able to use the investigations and the resultant actions as proof that the process brought positive changes back to the work place that improved safety. The lesson learnt from the investigations were used at toolbox sessions and helped in preventing similar occurrences.

During the course of the project, there were several other programs initiated to encourage the contractors attain higher standards. Some of these were applicable to individual contractors, others were developed collectively and rolled out site wide including.

- Hand protection and glove use
- Working at heights
- Confined space
- Housekeeping
- Barricading
- Vehicle safety
- Electrical Safety
- Isolations and zero energy testing.

Learning & Competencies

It was recognised that people cannot perform as expected unless they have acquired the necessary skills and competencies. The level of instruction and learning on the project was very high with all companies making a positive commitment in this area.

Induction training was given to all employees, covering:

- Generic Induction – Basic safety principles
- Hatch Induction – Site Rules, SOP's and JHA's
- Contractor Induction – Golden Rules and specific company procedures
- Work Area Induction – Job Hazards and Risk analysis.

Training programs, with assessment and verification, were produced by Hatch for the Standard Operating Procedures and the safety programs and safety initiatives. These were made available to the contractors for their use.

In all, a person on site could expect to spend up to ten hours a week in pre start huddles, formal training and toolbox meetings and supervisors would spend up to six days leadership and competency training before being ready for site. Add to this the time spent in JHA preparation, SBO's, inspections, RESTART programs and the time would be significantly more. The intensity of training and daily reinforcement was what kept the workforce focussed.

The Act also called for workers to be deemed competent to carry out designated tasks. This took the form of written and practical tests carried out by authorised Assessors or a Registered Training Authority.

Personal Changes by Individuals & the Workforce Culture

To mobilise a contractor and get acceptance and compliance with the site Rules and conditions and fully supporting the Safety Management Systems, took contractors, two to four months. Hatch worked closely with the contractors and helped them implement the systems. Over time, came a realisation that there was value in what was being asked for and the actions became more automatic and self sustaining. It was then that changes in the safety culture became evident.

As construction contractors mobilised to site at different times, the level of growth and development varied between work areas. It wasn't until well into the Project that some uniformity was achieved.

Hatch has witnessed the workforce change in the way individuals approach personal health and safety in the workplace and at home. Comments were made that "I will never again go back to how I worked before Hail Creek". This attitude is spreading and has been noticed on other projects, where workers from Hail Creek have been commended for the initiatives they brought to that site.

This culture has led to high levels of commitment and motivation in the workforce. However, the challenge was constantly there for managers and supervisors to maintain positive attitudes. Communication directly between Hatch's

Project Manager, Construction Manager, Area Managers and the workforce worked hard at this.

Hatch acknowledges the part the contractors played. The level of commitment by the on site Project Managers and their off site Management was an important factor in the successful coordination of the Site.

Innovations

The strong focus and level of effort expended by all site personnel allowed innovations in safety management to be made.

It was almost a case that managing safety became the "real" job. Building the coal mine was something that just happened as a consequence.

Over the construction period, using the methods and programs I have described, the Project was able to establish the following.

- Creating a working environment where safety was the major focus and driver of the team, rather than the traditional measures of time and cost
- Changing attitudes to working safely from a being a priority, which could change, to being a personal value and a way of life, that was instinctive
- Striving for consistency of performance across the contractors, by coaching training and attention to detail
- Being proactive and being ahead of the game, planning for what's coming up next and not being reactive
- Bringing the leaders together regularly to address common issues and arrive at acceptable solutions
- Sharing information on recent incidents, both on and off site, in a way that the information gets to everybody on site and then tool boxing lessons learnt
- Convincing people by leadership, perseverance, demonstration and encouragement that the methods are effective and letting them witness the results
- Ensuring by assessments and verification that we were employing trained and competent companies and people
- Stopping work or suspending operations if necessary to get peoples' attention and changing what they were doing
- Recognising and rewarding people who had displayed good safety behaviours and doing this regularly.
- Not being afraid of having a "WOW" experience on site that takes the workforce by surprise but gives an important message.

Several staff members, when they arrived on site, expressed the view that they didn't have time to attend another safety meeting, do another SBO, or go on another inspection. There was huge frustration at what they saw as an unrealistic level of effort required and for what? People were not going to change!

However, the issue was, that they were the ones who had to change. Once the individual made this realisation, they understood what was taking place and could move forward. They found that people can change and that continuous reinforcement and application can get you there.

This realisation, that change is achievable, is one that has come to nearly all involved with the Project. It is something they will take away with them.

The Results

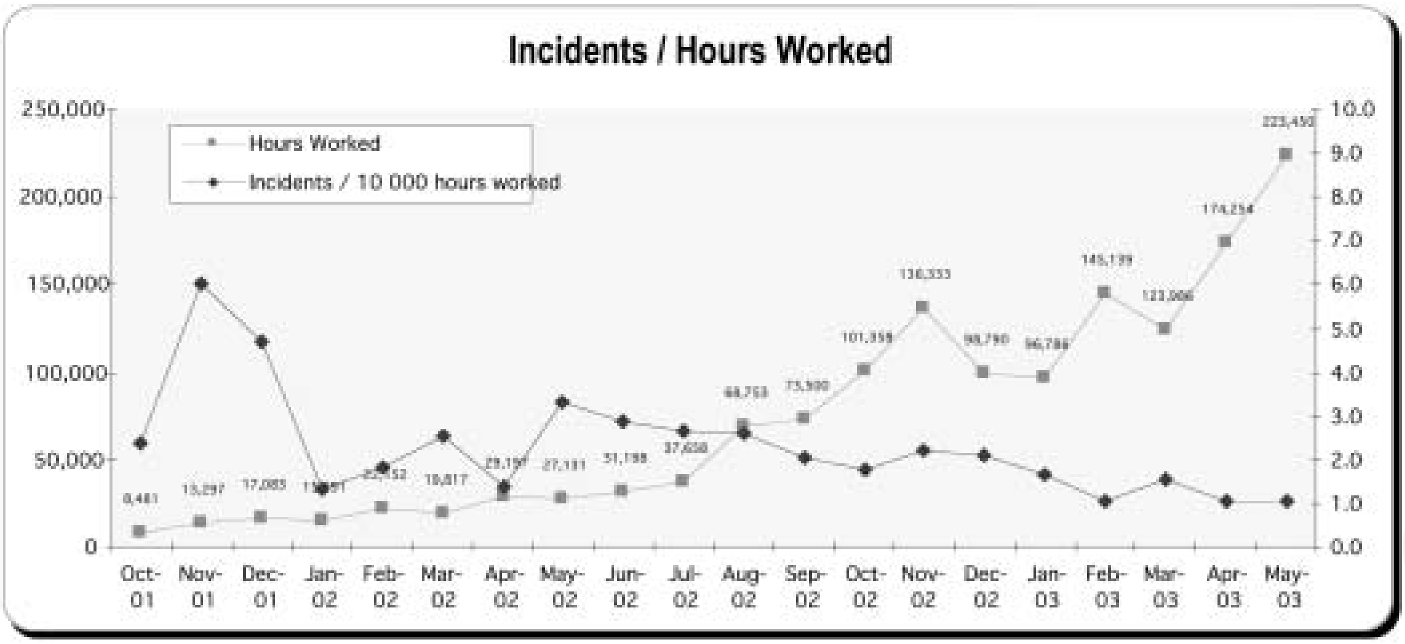
At the time of Hatch commencing on the project, industry safety indicators for Queensland were:

	Mining	Construction[2]
AIFR	17.3[1]	20.8[1]
LTIFR	6.8[2]	7.2[1]

Hatch's performance, over the nearly two years of the Project, has achieved an AIFR of 14.1 and an LTIFR of 2.3.

The following graph shows how our performance improved over time. It shows Incidents per 10,000 man-hours. Whilst the level of incidents is above where we want to be, the trend is healthy.

The path was difficult. The initial response from all contractors and many individuals was pushback and non-cooperation. They attacked the system as being "too rigorous; took no account of their years of experience; was too



overpowering; showed little in the way of trust and respect; was detrimental to safety; cost too much, took too long" and so on.

However, there are significant benefits the safety management system gave the Project:

- It reduced the level of incidents and injuries
- It provided a safe system of work across the contractors and participating companies
- It can deliver a competitive advantage in the market place
- It might cost initially but the paybacks more than compensate
- If planned properly, it took no longer so the program did not suffer
- The quality was better
- There was less re work
- There was a generally happier workforce with less hassles
- Better employee and industrial relations
- Less absenteeism.

In terms of lessons learnt, or what we would do differently, the following points are worth making:

- Strong leadership and support is required from a client
- Strong belief and commitment is required from all levels of management. The message has to be driven from the top down
- You cannot put too much effort into selecting your contractors and, in turn their site Project Managers
- A sound well thought out, relevant SMS must be available early in the Project
- Workforce participation and interaction is a powerful tool
- Risk workshops give good early notice of hazards and risk that require managing
- Construction is a sceptical industry, but will improve its safety performance if it can be demonstrated there are benefits
- It requires an exceptional effort to get an exceptional result.

The experiences at Hail Creek have initiated major advances to Hatch and all the participating contractors in making a step change in safety management, raising significantly the level of performance and the commitment to safety. There has been a significant shift in culture in a number of areas.

As a proof of the capability of the site's performance an audit by the NSCA in March 2003 gave the project a 5 Star rating at the first attempt. The NSCA auditors awarded 5 Star Certificates to Hatch and all the participating contractors. They commented "we have never seen anything as good as what we ran into up there". In late July, the MINEX Awards Evaluation Team visited us and we are hoping we will be successful at the Presentation Night in October.

With those sort of comments and recognition and the support from Hail Creek and the contractors on site, we are encouraged that Hatch has taken a big step for the industry towards providing an incident and injury free workplace.

References

1 National Workers' Compensation Statistics database.

2 Queensland Government, Natural Resources and Mines, Safety Performance & Health Report 1 July 2000 to 30 June 2001.

Where Safety is the Priority & Zero Harm is the goal

Ged Carroll, Ok Tedi Mining Limited

Abstract

Ok Tedi Mining Limited operates the largest open – cut copper and gold mine in Papua New Guinea with a workforce including contractors of about 3500 employees. The mine has been in operation for almost 20 years and is situated approximately 15 kilometres from the border of Indonesia.

OTML operates in a developing country environment with a multicultural indigenous workforce, difficult climatic conditions, in excess of 10 metres of rainfall per annum and the main mine workings located approximately 1700m above sea level, not to mention the numerous logistical challenges presented by our distance from major centres.

The risks when people, plant, equipment and environment are combined increases the potential for incidents to occur.

OTML promotes the slogan that **"Safety is Our Priority"** and **"Zero Harm"** our goal.

To achieve these objectives, we assess the risks and hazards confronting us at the commencement of every shift.OTML recognises that as an integral part of best business practice, all risks must be identified, analysed and managed professionally.

In order to achieve this, OTML has developed "in house" a highly sophisticated, and user friendly Integrated Risk Management System that is still evolving and which provides the Company safety efforts with the following attributes and capabilities:

- A structured risk identification process including contractor's risk
- An in - depth analysis of those risks utilising a numeric matrix methodology to avoid subjectivity
- A clearly defined evaluation of the risks
- A risk treatment profile with specific options for control or elimination
- An electronic action planning and tracking capacity
- A continuous monitoring, control and review system
- A risk communication strategy and process to embed the culture of risk management permanently within the workforce.

This process involves a dedicated team of key personnel from the respective OTML business units meeting on a periodic basis to systematically devise and implement methods to improve our risk management performance incorporating the following effort based actions:

- Initiation of actions to prevent or reduce the adverse effects of risk
- Control and further treatment of risks until the level of risk becomes acceptable
- Identify and record any problems relating to OTML'S management of risk
- Initiate, recommend or provide solutions through designated channels
- Action and verify the implementation of solutions
- Communicate and consult internally and externally as appropriate
- Documenting actions to provide accountability mechanisms and similar tools.

The development of the aforementioned systems reflect the fact that OTML considers all team members and operators as our "Frontline Risk Managers" thereby practically embracing the OTML message of Safety being our Priority.

Why Develop the Safety Risk Management System to such a High Level

A comprehensive risk management system supports high performance operations, low risk safe work practices and maximises stakeholder value by being industry competitive.

Historically the company managed risk within the various departments and this created some variances between methodology and systems used and the resultant data was frequently in several shapes and forms. The Integrated Risk Management system in addition to achieving site wide consistency assists in achieving OTML's Charter aspirations of Shared Purpose and Goals and identifies opportunities for continuous improvement.

Site wide centralised data handling is streamlined and more effective, operating through a central database allowing risks identified site wide to be flagged for action. Loop closing is enhanced by the in built action planning mechanism that allows automatic email alerts to be dispatched to the "risk" action owner 7 to 10 days prior to the end of a month requesting information on the status of the required treatment/action.

Reports can be generated to meet all business needs in descending order from board level down to individuals and departmental teams throughout the mine operating units.

In a recent external audit conducted by the NOSA Organisation the OTML team members were described as being "one of the most risk aware workforces we have encountered throughout our global site audits."

Risk Management Current Status

The Integrated Risk Management System is now being extended to other operational and business areas including environmental risk.

Consistent with this we:

- Use appropriate risk assessment techniques at all levels of the organisation and the resulting risk profiles are considered in decision-making
- Seek continuous improvement in managing threats and opportunities including taking business and stakeholder considerations into account
- Adopt and apply standards that reflect the company's commitment to risk management and continually review our performance against these standards
- Ensure that risk management systems not only identify, assess, monitor and control threats but also identify further development opportunities
- Ensure that all employees and contractors are informed and understand their obligations in respect of the policy, standards and guidelines
- Foster an ongoing risk knowledge culture by training and active participation and hold individual employees accountable for managing self risks and risks in their area of responsibility
- Comply with OTML's Risk Management Policy to eliminate fatality potential situations and sustain a "Zero Harm" work environment
- Provide a consistent, integrated, multidisciplinary approach and language for the management of risks associated with all hazards at OTML by implementing risk reduction strategies for unacceptable risks, maintaining controls for acceptable risks and further enabling risk-informed decision-making
- Ensure that management and staff know what is required of them regarding managing risk thereby enhancing vertical and horizontal communications
- Provide auditable criteria against which risk management activities can be measured.

Currently, OTML's Safety Risk Management System is the main proactive component of the Risk Management Program where individual and generic risks are identified, analysed, evaluated, communicated and treated to enable continuous improvement.

The system ensures that all hazards (threats) found to be unacceptable are urgently treated until the residual risk level becomes acceptable by means of Action Plans and the highest priority risks being treated first. Any risk scenario, which has the potential to adversely affect the safety or health of people or to cause damage to property or environment, is stored in the system.

Procedures are established and maintained for all personnel to identify and report hazards, incidents or any situation detrimental to safety or environment. Once risks scenarios have been identified, they are assessed with regard to the likelihood and magnitude of the potential consequences.

High and significant risks are evaluated and appropriately addressed, including actions, systems and arrangements for effectively managing these risks. Regular reviews of the status of registered risks and the effectiveness of control measures are conducted.

Control measures are prioritised and actions selected and applied in accordance with the risk management Hierarchy of Controls (i.e. eliminate, reduce, isolate, protect, etc.)so as to ensure that final risk levels are as low as is reasonably practicable. Appropriate levels of residual risk transfer are in place and monitored regularly for adequacy and coverage.

The natural Risk Owner or Risk Manager is identified and approached to accept this role for each Risk Treatment Action Plan. Risk allocations are based on the party's ability to control the risk and included into contract documents in the case of external parties. A Risk Manager/Owner is tasked with ensuring that such Risk Treatment Action Plans are implemented.

Some responsibilities are given to individual workgroups who are guided and encouraged to embrace a "Hierarchy of Controls" approach to manage and/or mitigate the identified residual risk inherent within their daily work duties.

The Risk Management Officer reports the progress of the risk treatment actions and any risk rating changes to all relevant personnel.

Risk Management System Elements

The OTML Risk Management System contains: policy and commitment; planning; implementation and operations; checking and corrective action; and management review elements.

- *Policy and Commitment* is aligned to the OTML Company Charter, OTML Risk Management Policy and Guidelines
- *Planning activities* involve the following process elements: context setting, risk identification, risk assessment and risk treatment planning
- *Implementation and Operations, and Communication and Reporting* element involves risk treatment plan implementation, monitoring and communication with all information generated capture on the Risk Register
- *Checking and Corrective Action* involves Outputs Measures and Performance Targets Indicator (KPI's) reporting and auditing feedback
- *Management Review* involves an annual management review and the development of a risk management system improvement plan.

Refer to Figure 1 to illustrate the elements involved in the continuous improvement loop.

Figure 1: Risk Management System Elements.

Risk Management Process

The risk management standard AS/NZS 4360:1999 has been used to guide all risk management activities carried out in the company. Figure 2 shows the steps involved and also list sub-steps in the establishing stage.

Continuous Risk Monitoring

It is our ultimate aim to ensure that a clear understanding of risk management performance and trends, and their significance and implications, exists at all levels in the company; and that performance measurement is utilised in the identification of adverse trends or situations and in the development of continuous improvement and corrective actions measures, as appropriate.

Outputs Measures and Targets are defined and utilised (Performance Management System) at all levels of operations at OTML. In addition, specific risk performance criteria and measures are defined for individual units, departments, as appropriate. In addition to maintaining standards of performance, such management tools are designed to facilitate.

The system has been established and maintained for the analysis of risk data, monitoring trends, applying corrective action and facilitating continuous improvement.

Figure 3 shows the OTML risk monitoring process, which ensure that the recommended corrective actions are implemented.

Figure 2: Risk Management Process. AS/NZS 4360: 1999.

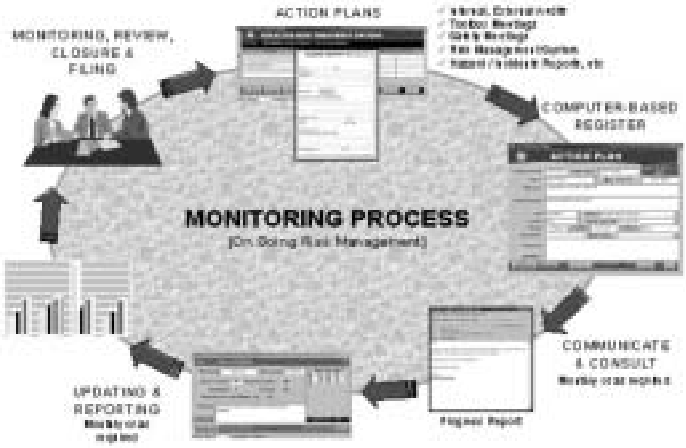


Figure 3: Risk Monitoring Process.

Risk Communication

Communication is an important element of risk management because it ensures that risk management performance is adequately communicated to all OTML personnel, that opportunities are regularly provided for effective two-way communication (vertical), that effective cross-communication (horizontal) exist throughout the company, and the systems are in place for the communication of risks to and from other parties as appropriate.

Once the critical risks scenarios are identified, they are communicated to the workforce using a "Risk Cascade" approach. This involves strategically positioned 3 x 1metre signage being installed in all key work locations to ensure that immediate work area risks are clearly visible to all employees or visitors and contractors.

Risks-based reports have been created and implemented to ensure that relevant, reliable and timely information is readily available to people inside and outside OTML who have the responsibility to act on such information and as required by legislation.

Communication of risk within the company is further improved by utilising OTML's television channel to flag potential risk scenarios to the broader workforce and indeed the community as the need arises.

Figure 4: Risk Communication Process.

The Road Ahead - Opportunities for Future Development

To quote OTML's Managing Director "to stand still is to fall behind." This statement encapsulates the philosophy and energy required by the company to move forward in an atmosphere of continuous improvement.

In order to meet stakeholder expectations we are presently expanding the database methodology to capture business and environmental risks.

This will allow us to manage and treat our environmental issues on a parallel basis to our safety risks and to ensure that our efforts are focussed and based facts rather than assumptions.

The Integrated Risk Management System is geared to provide us with a direct relationship to OTML's Performance Management process as we develop the capacity to align our safety and environmental risks through action plans, to set clear, measurable and challenging performance targets for all levels of employees within our organisation.

OTML has a "maturing workforce" and with that maturity comes a responsibility to ensure that our Occupational Health requirements are adequately assessed, risk rated and managed to achieve corporate standards of compliance The risk management system will assist greatly in ensuring that we accomplish this in a systematic and professional manner by undertaking a site wide occupational risk analysis and integrating the outcomes with that of our Medical Centre Management to ensure that we continually seek to mitigate occupational health risks for our workforce.

OTML is presently undertaking a major company wide information technology upgrade.

As the Integrated Risk Management System is designed on a Microsoft Access platform and requires minimal hardware and software support we aim to ensure that the system is fully linked and compatible to other important company databases and management systems such as MIMS, Concept (HR &Training) etc, to ensure that captured data can be easily shared / imported and aggregated in order that continually higher and more effective levels of planning and implementation occur. It also archives previous risk histories – allowing retrospective comparisons to be made.

In this way data can be easily manipulated by the system to meet the varying reporting requirements of a range of management, business units and specialist work teams.

Human resource initiatives are important also for the future as we aim to equip all of our key safety personnel and our site wide location risk teams with an accredited credential / qualification in Risk Management.

Summary

The system is continually "evolving" with each risk assessment session undertaken frequently highlighting areas where we can improve and better meet the needs of our clients and stakeholders.

The system is a cornerstone tool that is flexible enough to grow and develop to meet the organisations future Safety, Environment and Business risk needs.

The ongoing objective for the Integrated Risk Management System is to fully realise its potential as a first class continuous improvement and risk management tool.

Statistical achievements accrued during the implementation period of the Integrated Safety Risk Management System are listed below:

- OTML has achieved a fatality free mine site since the 19th of November 2001

- Between the 26th of August 2002 and the 25th of April 2003, OTML and contractors combined to record a total of 6,348,011 man hours Lost Time Injury free. Of this total, Contractors achieved 2,924,758, man-hours Lost time Injury free an OTML contractor record

- OTML's record and indeed a Papua New Guinea mining record achieved between 19TH of November 2001 and the 25th of April 2003 stands at 6,794,411 man-hours Lost time Injury free.

The "Study on Workplace Environment & Health":

An Efficient & Productive Collaboration in Occupational Health & Safety between Industry (WMC Fertilizers) & University (James Cook University)

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Abstract

In 2001, WMC Fertilizers Pty Ltd at Phosphate Hill commissioned the School of Public Health and Tropical Medicine (SPHTM) at James Cook University (JCU) in Townsville to develop, conduct and evaluate epidemiological research studies into the workplace environment and health as part of their pro-active approach to occupational health and safety. Over the last two years, this scientific project has been established as an efficient and productive collaboration.

The first part of this presentation discusses the key-features essential for the success and bilateral benefit of an occupational health research project in the specific collaborative setting between industry and university:

- Independence of Research
- Involvement of the Workforce
- Evidence-based Epidemiological Research
- The Objectives are Tangible Results Achieved in a Practically Relevant Time-Frame
- Cost-Effectiveness.

In the context of the "Study on Workplace Environment and Health", a range of practice-oriented research studies in occupational health and safety have been undertaken. The main goal of the research project was to achieve tangible results within a practically effective time frame. This goal has been fully accomplished and a variety of practical solutions and resulting improvements at WMC Fertilizers at Phosphate Hill were achieved.

Some components and results of specific studies will be discussed to examplify the practical research approach. These project cover the general areas of

- Chemical environmental sampling and mapping,
- Biological monitoring (annual health checks) and
- Dehydration and fatigue management.

Introduction

In 2001, WMC Fertilizers at Phosphate Hill commissioned the School of Public Health and Tropical Medicine at James Cook University (Townsville) to develop, conduct and evaluate epidemiological research studies into the workplace environment and health of the workforce at their Phosphate Hill operation. Identified potential health issues before the start of the project mainly related to chemicals in the workplace environment where hydrogen fluoride, and sulphuric and phosphoric acids were stated as potentially hazardous chemicals at the Phosphate Hill site.

The WMC Fertilizers plant at Phosphate Hill is located 150 km south-west of Mount Isa. The plant is a fly-in/fly-out operation and employees predominantly work a "2 on / 1 off ratio" schedule of 12 hour shifts. The climatic conditions at Phosphate Hill are harsh, with hot to very hot temperatures and an often extremely low humidity.

Considering the specific characteristics of the Phosphate Hill workplace, JCU identified the following main research areas:

- Identification and quantification of occupational chemical exposure
- Development and implementation of a chemical monitoring program
- Research into the potential (long-term) health effects of the identified chemicals
- Development and implementation of a biological monitoring program
- Research into dehydration and fatigue management.

The key features necessary for this research collaboration between a university and the mining industry to be successful are discussed, together with some the results of specific projects that exemplify the bilaterally beneficial nature of the research project in obtaining evidence-based knowledge and tangible scientifically valid results during practically relevant time frames.

Examples of projects discussed cover the general areas of (1) chemical environmental sampling and mapping, (2) biological monitoring (annual Health checks) and (3) dehydration and fatigue management.

Key Features of the Research Project

The following key-features are deemed essential for the success and bilateral benefit of an occupational health research project in the specific collaborative setting between industry and university:

(1) Independence of Research
Studies carried out by university researchers are independent and

consequently enjoy a higher credibility compared to consulting work carried out by agencies; this is also true with respect to the perceptions of the workforce. All content aspects of the "Study on Workplace Environment and Health" were developed by researchers at JCU. The role of WMC Fertilizers was restricted to logistical issues during the planning and conduct phase of the projects in contrast to many consultancy contracts where the employer often determines to a high degree the type, conduct and scope of the project. It should also be emphasised that full confidentiality of the information provided by individual workers is guaranteed as WMC Fertilizers only has access to summary (as presented in the respective reports), not individual data.

(2) Involvement of the Workforce
The importance of workforce involvement as a vital component of any epidemiological study cannot be overestimated. Above all, in this area of workplace health and safety, the employees can contribute indispensable information (it's their workplace after all!) and the quality of quantitatively collected general health information is directly related to the support of the workforce. The involvement of the workforce covers two main areas; active participation and regular feedback. The presented study incorporated from the outset a variety of different measures for ensuring involvement in both areas.

Active participation: Annual qualitative focus group research is carried out in many segments of the workforce (usually 6 different groups) for the employees to have their say. Here the participants discuss with JCU researchers their perceptions of workplace and safety issues (including suggestions for improvement) and the performance of the management and the safety department in their working area. Additional questions also refer to their view of recent projects.

Feedback: Regular feedback to the workforce is achieved by publishing each JCU report uncensored and in full length on the WMC Fertilizers intranet (this accessibility to the full information gained is also a hallmark of independent research!). For specific aspects of the study, special "information flyers" summarising the findings in plain language are also provided. Moreover, JCU features prominently during a "safety day out" at least once per year providing presentations followed by discussions on every individual project carried out on site. Additionally, the workforce and their families are kept up-to-date by regular contributions to the "Fertilizer Facts", the monthly site magazine.

(3) Evidence-based Epidemiological Research
The independence of the research also guarantees that JCU researchers can follow stringent scientific methodology, with the consequence that the results of the studies and the developed policies and procedures are strictly evidence-based and therefore valid. It is important that the beneficiaries of any type of study and research in the area of occupational health and safety are people, in this case, the employees. JCU has therefore implemented as much epidemiological studies (i.e. studies referring to actual people) as is possible.

(4) The Objectives are Tangible Results Achieved in a Practically Relevant Time-Frame
In contrast to some pure academic research, it is imperative that the main focus of an industry-university collaboration is on achieving practical solutions. JCU adopted this principle and the components of this study discussed below will exemplify the achievements in this area in more detail. In general it can be stated that the study has been running for two years and had to "start from scratch" in terms of epidemiological data. Considering this, the practical outcomes, also for previously unknown issues, seem impressive.

(5) Cost-Effectiveness
University research not only offers the previously discussed advantages of independent and credible scientific research, but is also highly cost-effective. The "Study on Workplace Environment and Health" enrolled several doctorate students from the School of Public Health, while a smaller research study into the hydration knowledge and behaviour of the workforce was conducted with the help of undergraduate students as part of one of their research methodology subjects.

The involvement of doctorate, graduate and undergraduate students, if carried out under strict supervision of a senior experienced person, is not only cost-effective but in this particular case also beneficial to all parties involved (the industry partner, the university and the students) in the following way: The students learn practical skills through their early exposure to "real-life" epidemiological research and are led to the field of occupational health and safety in the mining industry, an identified area of personnel shortage where employment opportunities for future graduates seem quite promising.

The "Study on Workplace Environment & Health" Examples of Components & Results

Having considered the key features of the "Study on Workplace Environmental and Health", some examples of components and results achieved in different areas of occupational Health and safety by the project are presented in the following.

In the order of their discussion, these components exemplify practical research studies and their results in the areas of:

(1) Chemical environmental sampling and mapping
(2) Biological monitoring (annual Health check-ups) and
(3) Fatigue and dehydration management.

(1) Environmental Chemical Sampling & Mapping

Environmental chemical sampling of the atmosphere was undertaken as part of the JCU study. The air was sampled for a range of chemicals of potential concern. Sampling has so far been conducted in two phases: (1) predominantly "uniform sampling" in 2001 and (2) primarily "targeted sampling" in 2002.

The objective of the first sampling operations was to provide a 'snapshot' of what might typically be observed in the atmosphere at the WMC Fertilizer site under routine operating conditions. During this first sampling phase the majority of the sampling points were equally spread in a regular grid over the whole site, while only the smaller part of the sampling points was concentrated in finer grids around the suspected sources.

The second phase of sampling was deliberately and highly "biased" towards detailed sampling at and around the identified sources of the first survey but nevertheless kept a wider grid over most of the rest of the site to confirm (or otherwise) the general pattern of distribution of the chemicals observed at the site during the initial sampling program.

The main chemicals sampled and measured were:

• Hydrogen Fluoride (HF)
• Sulphuric Acid (H_2SO_4) and
• Phosphoric Acid (H_3PO_4).

The sampling methodology was designed to ensure that the detection limits for these chemicals were at least a factor of 10, and for HF close to a factor of 100 below the National Occupational Health and Safety Commission (NOHSC) Time Weighted Average (TWA) values.

Detection limits and NOHSC TWA for the main analytes were 0.03 (mg/m^3) and 2.6 (mg/m^3) for HF, 0.1 (mg/m^3) and 1.0 (mg/m^3) for H_2SO_4 and 0.03 (mg/m^3) and 1.0 (mg/m^3) for H_3PO_4 respectively.

Approximately 200 samples (6 hour time weighted average) were obtained for the main analytes during the two sampling programs. The initial sampling phase demonstrated that detectable HF concentrations were localised in and around the Phosphoric Acid plant and on the Gypsum Stack. These locations were consequently the main focus for the second sampling operation and detailed concentration maps were obtained for these areas, such as the filter floor of the phosphoric acid plant where a grid of 25 measurements was taken.

The main results for the Phosphate Hill site referring to around 200 (6 hour averaged) samples (taken as above described) can be summarised as follows:

(1) Only one single sample of **phosphoric acid** exceeded the detection limit of 0.03 mg/m3 with a result of less than 6% of the NOHSC TWA.

(2) Twenty-three samples of **sulphuric acid** mist exceeded the detection limit of 0.1 mg/m3 during the first sampling phase and only one single sample during the second sampling program despite the above described deliberately biased sampling procedure. All quantities above detection limit were below 15% of the NOHSC TWA with the exception of four samples collected at the filter floor of the phosphoric acid plant where levels up to 75% of the NOHSC TWA were seen. The sole sample above detection limit of the second sampling phase reached approximately 10% of the NOHSC TWA.

(3) **Hydrogen fluoride** was detected in 40% and 60% of samples during the first and second round of the sampling program respectively. The typical concentrations of detectable hydrogen fluoride around the site were below 4% of the NOHSC TWA with two marked exceptions; the phosphoric acid plant and its immediate surrounds and the gypsum stack where three samples (2.6, 2.7 and 2.8 mg/m^3) revealed concentrations at or above the NOHSC TWA of 2.6 mg/m^3.

The interpretation of the results from the two sampling programs can be summarised by stating that, *under routine operating conditions*, the sampled chemicals do not appear to imply a significant risk to human health at the Phosphate Hill site. It seems worth noting in this context that the only three samples revealing values at or above NOHSC TWA were obtained at locations where the use of PPE is compulsory.

The general agreement of the results for all analytes between the two sampling operations indicates that the two surveys provide a valid overview of the spatial distribution of the sampled chemicals around the Phosphate Hill site. The only observed differences between the sampling operations disappear when the relative frequency of the samples at the respective sites is taken into account. For instance, the observed increase of detectable amounts of hydrogen fluoride between the two sampling programs is explained by taking the deliberately biased sampling strategy for the second sampling phase into account.

The only exception is the filter floor of the phosphoric acid plant where the observed decrease in detectable amounts of sulphuric acid between the two sampling programs is attributable to engineering solutions. The significant decrease in samples containing a detectable amount of sulphuric acid mist (despite the increased sampling frequency around the phosphoric acid plant) therefore demonstrates the effectivity of the implemented structural solution.

(2) Biological Monitoring

As part of the biological monitoring process of the JCU study at Phosphate Hill, a quantitative Health Survey has been conducted annually since 2001. All employees of WMC Fertilizers, as well as all contractors at Phosphate Hill, are invited to participate.

The main aims of this annual Health Survey are to:

1) Determine the general health status of the workforce
2) Create a baseline of the general health status as reference data for future monitoring and/or surveillance projects and for quasi-experimental intervention studies
3) Identify attributable fractions of relevant risk factors (occupational history, diet, smoking, alcohol etc)
4) Identify specific priorities for intervention strategies; and
5) Contribute generally to a safer working environment.

The main components of the Health Survey comprise:

a) A full blood count, a liver function test and an ACR urine test
b) A full respirometry (including changes after the use of dilators)
c) A basic physical examination (including visual acuity, joint laxity, blood pressure); and
d) A detailed health questionnaire covering basic demographics, medical and occupational history, individual risk conditions and behaviour, current medications, smoking, alcohol consumption and detailed symptoms pertinent to potential exposure to hydrogen fluorides and other relevant chemicals.

Personal confidential letters are delivered to each participant detailing their results of the Health Survey.

The Health surveys are well received by the workforce and this is reflected in a high participation rate (around half to two thirds) of the overall workforce. Taking into account that a substantial percentage of this "overall workforce" are contractors who are not necessarily on-site on a regular or permanent basis, the overall participation rates may even exceed the above estimates.

The main aim of this series of health surveys is the biological long-term monitoring of the workforce and to obtain baseline information for future quasi-experimental intervention studies. Therefore, the general results do generally not lend themselves to stand-alone interpretation. However, some findings can be directly used to develop specific recommendations towards health improvements of the workforce and are discussed in the following.

More than one-quarter of all staff (compared to less than 20.0% of the Australian population[1]) have a Body Mass Index (BMI) that is in a high-risk category for hypertension, cardiovascular disease and diabetes. Every third participant has a high-risk waist-to-hip ratio and close to half of the participating workforce is hypertensive, which both impose a substantial health risk with respect to a variety of cardiovascular diseases and seem worth addressing. Similar statements hold true for the observed high prevalence of (and likely synergisms with) smoking (35% compared to 24% for the Australian population) and significant levels of alcohol intake.

Consequently, the roles of Eurest in providing nutritional information and low-fat food options and Trench Sportz in facilitating physical activity on-site seem justified. In this context, it seems worth noting that employees are significantly more likely to engage in physical activity on-site (median 5 days) than off-site (median 3 days).

The main focus of the overall study, however, is on workplace environment and occupational health and therefore specific intervention programs to change the general life-style seem beyond the scope of this project.

Almost every fifth participant of the first survey would have failed the Queensland Transport heavy vehicle visual acuity test. This is disquieting, despite the fact that the visual acuity test (using only an eye-chart) cannot be regarded as a final diagnosis, and may actually overestimate the proportion of subjects with compromised visual acuity.

A potentially compromised visual acuity was of course mentioned in the confidential personal letters and the apparently high percentage of such findings intensively discussed in the respective health reports and JCU presentations on site. The respective percentage observed during the second health survey was 5% with a coinciding increase in the use of a corrective lens. However, whether this improvement was attributable to the described “interventions” remains unclear since the illumination of the eye chart seems to have been unfavourable during the first health survey.

An interesting finding with respect to respiratory parameters was the observation that some employees had been previously diagnosed with and were currently suffering from asthma. This constitutes a major workplace health risk as it is known that exposure to inorganic gas mist and dust – above all in combination with physical activity – vastly increases the risk for asthma attacks and potentially serious consequences[2]. The result also indicated that the screening for asthma performed during routine entry examinations prior to employment was sub-optimal.

As a consequence, a detailed proposal for a more effective pre-employment medical has been developed by the JCU team and the logistics for the amalgamation of this proposal with new corporate guidelines are currently under development.

Additionally, those employees identified with a history of asthma or breathing obstruction were encouraged to develop an asthma management plan with their General Practitioner to control and reduce the severity of their symptoms[3].

While participants in this study have only marginally less usual hours of sleep per night on- than off-site (median of 7 compared to 8 hours), more than twice as many have less than 4 hours sleep on at least one night on-site (45%) than off-site (18.0%). Sleepiness, in combination with low blood alcohol concentrations and dehydration may influence injury risk and productivity and currently implementations of random tests (such as simple reaction time, dual task Mackworth clock vigilance and symbol digit coding) are considered as assessments[4] of fatigue.

The biochemical blood analyses, self-reported symptoms and the observed colour of the collected urine samples indicated considerable levels of dehydration in the workforce which led to the dehydration studies which are discussed in the following.

(3) Dehydration Study

The series of dehydration studies illustrate the dynamics of the research process. Dehydration was identified as an important issue during the standard components of the project and led to a variety of interesting specific research projects.

The first observation leading to this process was that approximately 16.0% of the workforce exhibited elevated serum albumin levels and 10.0% of the workforce had elevated serum albumin and potassium levels in combination. Both are biochemical markers for dehydration[5]. Additionally it was observed that the most frequent self-reported symptoms in the health surveys were all discussed in the literature as closely associated with dehydration[6]; over 40% reported tired or strained eyes, and close to 40% stated unusual fatigue and headaches during the last 4 weeks while working on-site. A further indication for dehydration as a workplace issue came from the qualitative focus groups where people again complained about symptoms consistent with dehydration.

Consequently, a study of the hydration status and hydration needs of the workforce was conducted and is reported in detail in an additional contribution to these proceedings. The main aim was to determine the hydration status and hydration needs by measuring urine specific gravity (portable refractometer), fluid intake (questionnaire) and fluid loss (difference in weight and specific questionnaire items).

This study found that two thirds of the workforce maintain or improve their hydration status during their shift but those working predominantly in direct sunlight need to improve their hydration behaviour. Data collected for this study also allowed the development of detailed weight and task specific fluid input targets. The most surprising result, however, was that a majority of the workforce *arrived* dehydrated for their shifts.

The prime target for improving the hydration status of the workforce consequently shifted from the workplace to the camp, and an additional study was carried out on the hydration knowledge of the workforce and their hydration behaviour at camp. Third-year Occupational Therapy students were involved in this project (as part of their research studies) and developed, piloted, adjusted and then administered a questionnaire to the workforce in April/May this year.

At the time of writing, some data were still being analysed in detail. However, the main results clearly demonstrate that while the general hydration knowledge (risk factors for dehydration, what type of drinks are actually dehydrating etc.) of the workforce is adequate, people simply don't seem to drink enough non-alcoholic beverages at camp. The stated averages of one "cup"-equivalent of soft drink and 2 "cups" of water are by far not sufficient to keep a person adequately hydrated.

Why is there a discrepancy between knowledge and behaviour? One answer was found in the perceived obstacles to re-hydration in the questionnaires: Half of the comments stated referred to the perceived poor taste of the tap water at camp and a similar proportion of comments relate to access to alternatives to tap water such as bottled water.

A number of possible practical solutions on how to most effectively address this critical issue are currently being investigated. These include possible "engineering" solutions (such as implementing additional water filters, increasing the number of water fountains at camp, etc.) but will also have to bridge the gap between hydration knowledge and the respective behaviour by means of information campaigns and other educational interventions.

The research process in the area of dehydration at Phosphate Hill is still in progress but the series of the above described projects clearly demonstrates the dynamics and often multi-stage character of a practical research process.

Starting with the biochemical findings of the Health surveys indicating a dehydration problem and the confirmation of the identified issue by results from the qualitative focus group research, a specific study on the hydration status (and hydration needs) of the workforce was developed and conducted. The results of this third stage of the research process demonstrated that the main problem lies at camp. Digging even deeper, an additional survey of the hydration knowledge and hydration behaviour at camp was undertaken to identify the "ultimate" causes. Preliminary results of this survey point to the taste of the tap water and an underestimation by the employees of their susceptibility to and the consequences of dehydration.

Once these results are confirmed and effective interventions have been developed and implemented the research process can be "reversed". The next stages will then be the process, impact and outcome evaluations of the interventions employing another series of studies (Figure 1).

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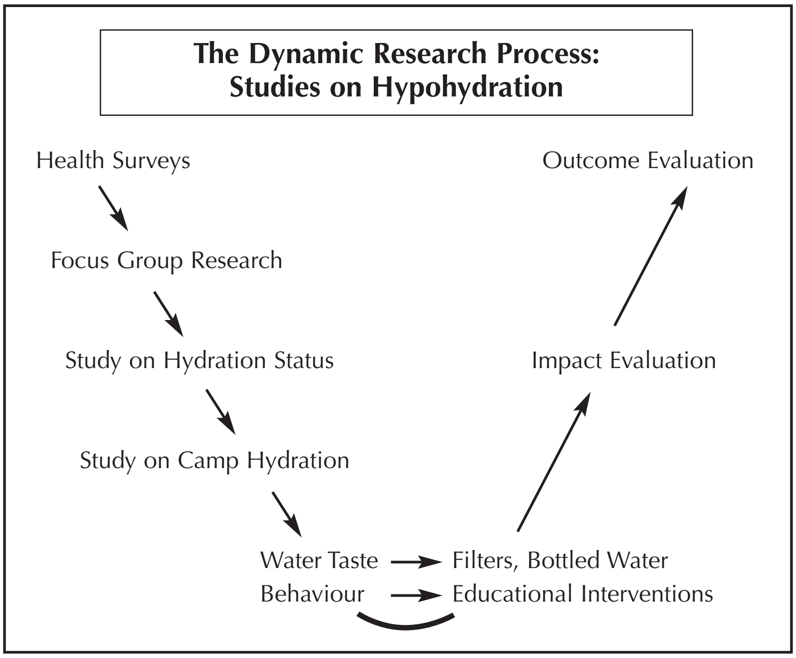

Figure 1

An AcciMap of the Esso Australia Gas Plant Explosion

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Abstract

This paper presents an AcciMap (causal diagram) of an accident at Esso's gas plant at Longford in Victoria. The AcciMap is used to show how factors quite remote from the immediate accident sequence contributed to the accident. Parties at the Royal Commission which investigated the accident were quite selective in the causes they emphasised. The paper identifies three principles of selection which were used: self-interest, accident prevention and legal liability. The interested reader will find full details of this accident in my book (Hopkins, 2000).

On 25 September, 1998, an explosion occurred at an Esso gas plant at Longford, near Melbourne, which killed two men and interrupted the gas supply to the state of Victoria for two weeks. Because of the economic cost of this disruption the state government set up a Royal Commission - the most powerful inquiry possible. The inquiry uncovered an intricate causal network, ranging from front line operator error right back to company and even government policy. This paper will outline the causal network by providing an AcciMap of the incident (Rasmussen, 1997). A number of features of the map will be explained in the next sections. The paper will then examine the strategies of causal explanation used by the parties represented at the inquiry.

The Accident Sequence

Level 1, the bottom level of the diagram, lays out the events - physical processes and operator actions - which constitute the accident sequence. The two irregular stars represent the critical outcomes – explosion and loss of gas supply. The circles represent the operator errors which contributed to the accident. The sequence starts with the incorrect operation of a bypass valve which allowed condensate to spill over into other parts of the system eventually causing the failure of the warm oil pumps. This led to a metal heat exchanger becoming super cold and therefore brittle. Operators then made the error of restarting the warm oil flow which caused the heat exchanger to fracture, allowing a large volume of gas to escape and ignite. Two men were killed and eight others injured. Two other gas processing plants on the same site were not effectively isolated from gas plant 1 where the accident occurred, with the result that gas supply from all three plants at the site ceased. And because there was no alternative supply, Victoria was in chaos for two weeks.

Increasing Causal Remoteness

The vertical axis involves a series of levels, increasingly remote from the accident sequence just described. There is a certain amount of arbitrariness in the division into five discrete levels, but the basic principle is - the more remote the cause, the higher up the diagram it is located. The five levels are physical, organisational, company, government/ regulatory and societal.

The Causal Connections

The arrows in the Figure 1 are to be understood as meaning cause in the following sense. One thing is said to be a cause of another if we can say: *but for* the first, the second would not have occurred.

Defining cause in this way has various consequences. First, there is a theoretically unlimited number of factors or circumstances giving rise to any particular event; those represented here are ones which came to light at the Royal Commission. It should be acknowledged, too, that not all the causal factors identified in the inquiry are dealt with here. In particular, metallurgical causes have not been included.

Second, the definition implies that had any one of these causal pathways in the diagram been absent the outcome would probably not have occurred. In particular, where more than one arrow enters a box, all are necessary preconditions. There is an implied logical AND in the diagram at such points.

Third, this notion of cause involves imagining an alternative (counter-factual) situation and inferring how things would have turned out had this imagined situation existed. Obviously this is a speculative exercise and we are strictly only justified in speaking about likely or probable outcomes. Most of the causal statements implied in the diagram need to be understood as qualified in this way.

Drawing an AcciMap has the particular advantage of clarifying the nature of the causal chains leading to the accident. It shows precisely how events or conditions quite remote from the accident amounted to essential preconditions. In the next section of the paper I should like to trace some of these chains, and readers will need to refer continually to figure 1. I shall not provide a complete explanation of the diagram; readers wanting more detail should consult Hopkins (2000).

The Absence of Engineers

Bourrier (1998) has shown how one way of ensuring high reliability operation in hazardous facilities is to maintain relatively large numbers of engineering staff to oversee the work of plant operators. Where procedures need to be modified to get the job done, engineers can supervise the modifications to ensure that there are no unintended consequences. Where qualified engineering staff are absent, plant operators are likely to modify procedures themselves in ways which may not be optimal and which may lead, in the long run, to disaster.

This is what happened at Longford. Engineers who had been previously been employed on site were withdrawn in 1992, as part of a cost cutting strategy. Changes to plant design, which were made after that time, turned out to have problems, which were not properly addressed by engineers from head office in Melbourne. Moreover, the absence of engineers meant that plant operators were not properly supervised. The result was that in order to deal the with problems they were encountering, operators were forced to run the plant routinely in alarm mode. This de-sensitised them to the significance of alarms and led to an operator error, "incorrect bypass valve operation", which initiated the accident sequence.

A further consequence of the absence of engineers on site was that there was no-one to warn plant operators against reintroducing warm oil into the super cold heat exchanger.

The AcciMap, then, shows how the absence of engineers contributed in a complex and multi-stranded way to the explosion.

Focus on LTIs

Esso measured safety by its lost–time injury rate. It was extraordinarily successful in reducing this figure effectively to zero. But the consequence of this emphasis was that the company paid insufficient attention to the management of major hazards. The AcciMap highlights just how this focus on LTIs led to the accident.

First, it distorted maintenance priorities. Equipment which was judged to be safety-critical was given a high priority. But since the safety focus was on LTIs, the judgements were about whether the equipment breakdown was likely to cause routine slips, trips and falls. No attempt was made to ascertain whether the breakdowns might affect plant safety. The result was that a valve which was critical for plant safety was left unrepaired for two weeks, requiring operators to operate a bypass valve manually. Incorrect manual operation began the accident sequence.

There was a second way in which the focus on LTIs contributed to the accident. The incident reporting system was used to report incidents which caused or had the potential to cause LTIs. It was not used to report process upsets which had the potential to endanger the whole plant. Thus, one month before the accident, there was an incident involving loss of warm oil flow and abnormally low temperatures, so low that ice formed on pipes normally too hot to touch. By good luck rather than good management, this incident did not lead to disaster. Unfortunately, it was not reported in the incident reporting system. Had it been, it would have been thoroughly investigated and steps taken to prevent a recurrence. The steps would have involved new procedures about what to do in the event of loss of warm oil flow, and training in the those procedures. Had this training and been provided, the crucial mistake of restarting the warm oil system would not have been made on the day of the accident.

Poor Auditing

A major audit by Exxon prior to the explosion gave Esso a clean bill of health. It was an audit which failed to convey any bad news to Esso's board of directors. Any audit which conveys only good news is a bad audit. Two particular failures will be mentioned here. First, although the audit examined the incident reporting system, it failed to notice that the system was not being used to report major process upsets, not even system shutdowns.

Second, the audit failed to pick up that a basic hazard identification procedure, called a HAZOP (hazard and operability study), had not been carried out at gas plant 1 where the accident happened. The two other gas plants on the site had been HAZOPed, but despite an Exxon policy introduced in the early 90s in favour of HAZOPing all existing plants, Esso deferred indefinitely a plan to HAZOP gas plant 1, on the grounds of cost.

Had this HAZOP been carried out, it would have identified the possibility of the loss of warm oil flow and the consequent embrittlement of certain metal pressure vessels. The recognition of this danger would have led to the development of procedures and training to deal with the possibility, and this certainly would have precluded the operator error which triggered the explosion.

Exxon Control Failure

Exxon operated a policy of decentralising responsibility for safety. Although it encouraged Esso to HAZOP its plants it did not exercise any control over subsidiary companies in such matters and so, Esso was free to defer the HAZOP of GP1 indefinitely.

Furthermore, gas plants 1, 2 and 3 were tightly connected and the explosion at the first put the other two out of operation for two weeks. This led to total loss of gas supply to the state of Victoria for two weeks. Esso had failed to identify the hazards of interconnection and Exxon had failed to instruct its subsidiary in this regard. The hazards of interconnectedness were highlighted in the Piper Alpha explosion, where gas from other platforms fuelled the fire on Piper Alpha. This is exactly what happened at Longford: gas from other plants fuelled the fire in gas plant 1. Exxon's policy of decentralising responsibility for safety meant that Esso Australia was free to ignore this critical lesson from Piper Alpha.

The Inadequate Regulatory System

To claim that a regulatory system was a cause of an accident may seem artificial. I shall show in what follows that it was, indeed, a cause in the "but for" sense. The legislation which applied at Longford was the Victorian Occupational Health and Safety Act which emphasises self-regulation and seeks to minimise prescription. On the other hand, both upstream of Longford, in the offshore oil fields, and downstream of Longford, in the Victorian gas pipeline system, safety case regimes applied. A safety case regime requires that employers make a case to a regulatory authority showing how they have identified all hazards and describing the control strategies which have been adopted. Had such a regime been in place at Longford itself, it would almost certainly have resulted in Esso carrying out a HAZOP of gas plant 1 which would have identified the hazards which led to the explosion. Moreover, the federal government had recommended the safety case regime be implemented at major hazard sites like Longford, but the state government had not done so. It is on this basis that it can be said that: but the failure of the state government to impose a safety case regime on Esso at Longford, the accident would not have occurred.

Government Failure to Provide Alternative Gas Supply

Esso was the only supplier of gas to the state of Victoria and the state was therefore very vulnerable to any loss of supply from Longford. Although the government accepted responsibility for security of supply, it had not developed storage reservoirs in Victoria or any pipeline connections with suppliers interstate, which would have enabled temporary interruptions of supply from Longford to be dealt with. One party at the Commission argued that the government's failure in this respect was due to its ideology of privatisation and small government. This particular argument was not supported by the evidence and is indicated by a dotted line in the diagram.

Market Forces

At the top of the diagram, is what I have termed the societal level. We live in an increasingly global, capitalist society in which competition and the market affect most aspects of our lives. Market forces generated sustained cost-cutting by Esso throughout the 1990s which contributed to the accident in a number of quite specific ways. It was the reason engineers were withdrawn from the Longford site; it was the reason for the maintenance backlog; and it was the reason why the HAZOP of gas plant 1 was deferred indefinitely. Each of these contributed to the accident in ways which have already been discussed.

The impact of market forces on safety at Esso's Victorian gas plant was part of a much broader pattern. In the UK, the oil industry formalised its drive to reduce costs in what was called the Cost Reduction in the New Era (CRINE) initiative. CRINE sources asserted that "capital and operating costs have continued to escalate … (and) unless urgent action is taken to reverse this trend, the future of oil and gas development in the UK North Sea will be in serious jeopardy" (quoted in Whyte,1997:1151). The threat was from the international market place, in particular, cheaper production costs in Mexico, Vietnam, the Maldives, China, Indonesia and Malaysia. Toombs and Whyte (1998) argue that that resources available for safety in the North Sea increased in the aftermath of the Piper Alpha disaster in 1988 but that the cost cutting associated with CRINE saw a reduction in safety-related spending and a consequent impact on safety.

Moreover, the cost-cutting imperative drove large corporations in the 1980s to decentralise (Baram, 1997), which meant that head offices handed over responsibility for safety to operating subsidiaries. Consequently, in matters of safety, companies like Esso Australia were not subject to effective control by their parent company.

Principles of Selection

Numerous parties were represented at the Royal Commission and none of them acknowledged all the causal factors identified above. In their closing submissions, each emphasised particular causes. The rest of this paper explores the principles of selection, or "stop rules" (Rasmussen, 1990) which they used. Three distinct principles will be discussed below and can be summarised here as follows.

- *Self-interest:* select causes consistent with self-interest
- *Accident prevention:* select causes which are most controllable
- *The legal perspective:* select causes which generate legal liability.

Self Interest

Where parties had financial or reputational interests at stake, this guided their selection of cause above all else. In particular, those seeking to avoid blame or criticism focussed resolutely on factors which assigned blame elsewhere, and denied, sometimes in the face of overwhelming evidence, the causal significance of factors which might have reflected adversely on themselves. Esso blamed the whole accident on errors by plant operators and denied that any of the organisational failures uncovered by the Commission played any role in causing the accident. On the other hand, counsel for Esso's workforce blamed the whole accident on Esso's negligence.

The Insurance Council of Australia was likewise guided by financial interest in identifying negligence by Esso as the cause of the accident. The interruption of gas supply to Victorian industry had caused more than one billion dollars worth of damage, and much of this was borne by insurance companies. They were thus out to recover from Esso and had a strong interest in a finding of negligence against Esso by the Commission. They therefore emphasised causes at level 2 of the diagram.

Finally, the Victorian government was politically vulnerable to any criticism that government policy might have contributed to the loss of supply. Both the government and the regulatory agency responsible for health and safety were represented at the inquiry. Both argued that Esso alone was responsible for the accident and that neither the government, nor the regulator, nor even the regulatory system was in any way to blame. Again the causal focus was at level 2.

It is obvious that parties with direct interests will be guided by these interests in their selection of causes. Only where the participants have agendas not based on immediate self-interest, can other principles of causal selection come into play.

Accident Prevention

A second principle was followed for participants whose primary concern was accident prevention. It was to focus on causes which are controllable, from the participant's point of view. Counsel Assisting the Commission adopted the accident prevention approach and viewed the task of prevention from the perspective of management. He therefore emphasised causes at the organisational level, since these are within the capacity of management to control. He had little to say about causes at higher levels and, interestingly, nothing to say about the physical causes at level 1.

The peak labour council in Victoria was also concerned about accident prevention. It had no direct influence over Esso and therefore no capacity to bring about the kinds of management changes in Esso which might prevent a recurrence. However, it did have the potential to influence government and government agencies. Its strategy, therefore, was to seek changes in the regulatory system which would compel Esso and similar companies to improve their management of safety. This was the point in the causal network where its intervention was likely to be most effective. Hence it emphasised the inadequacies of the regulatory system as the cause of the accident.

The Legal Perspective

The Royal Commissioners themselves adopted a third principle of selection, namely to focus on causes which generate legal liability. The Commission was asked under the terms of reference to consider whether breaches by Esso of relevant legislation had contributed to the accident. The factors which most directly created legal liability under the Victorian OHS Act were lack of appropriate training and procedures to deal with the problem of loss of warm oil flow. Accordingly, the Commissioners found that these were the “real causes” of the accident. The special status of these causes is indicated on the AcciMap by the use of an octagonal box. The Commissioners recognised most of the other factors sketched on the AcciMap, but they described them as “contributing factors”.

It needs to be noted that, for some parties, more than one of these principles was at work. For the Insurance Council of Australia, for example, the principle of self-interest coincided with the principle of selecting causes which generated legal liability.

Exclusions

Principles of selection are necessarily also principles of exclusion. Two causes identified above were not selected for emphasis by any of the participants - market forces and Exxon’s hands-off approach. This is worth elaborating.

Exxon was not a party to the proceedings, nor was its contribution to the accident investigated, partly because of the way the terms of reference for the inquiry were drawn. Although Exxon’s management style was, as I have argued, a critical contributing factor, none of the three principles invited a focus on Exxon’s contribution by any of the parties.

The other factor ignored by all parties, despite the fact that, in an important sense, it was the ultimate cause of the disaster, was the market. There are obvious reasons for this blind spot. Capitalist society is a given – the taken-for-granted context of the world of work. There is no realistic prospect of cutting ourselves off from global, market society in the interests of accident prevention. Moreover, many would argue that, for other reasons, such a course of action is not even desirable. There was therefore nothing to be gained for any participant by drawing attention to this ultimate cause.

However, the market is a cause which governments motivated by accident prevention concerns would do well to acknowledge. Cost-cutting pressures stemming from market forces are pervasive and inevitable. It is these pressures which led to the organisational failures which have been identified. Safety depends, therefore, on bringing to bear countervailing pressures, and this is the role of government, via its regulatory system. It is vital that governments adopt regulatory strategies with the potential to over-ride cost-cutting imperatives so as to ensure that companies adopt and effectively implement the necessary management systems.

Conclusion

This paper has demonstrated the value of the AcciMap in describing the chains of causation which led to the accident at the Esso Longford gas plant. It has shown, too, that interested parties chose from among three principles in deciding which causes to emphasis: self interests, accident prevention and legal causation.

The strict “but for” logic used in constructing this particular AcciMap means that breaking any one link in the network of causation would probably have averted the accident. AcciMaps constructed according to this logic are therefore useful tools for anyone interested in accident prevention. They suggest a wide variety of ways in which accidents can be prevented. Moreover, they suggest ways in which people at many different locations both inside and outside the organisations concerned can contribute to accident prevention. Some writers have argued that the complexity of the accident causation process makes accidents inevitable (Perrow, 1999). The implication of the AcciMap analysis is that this very complexity is what makes accidents so preventable.

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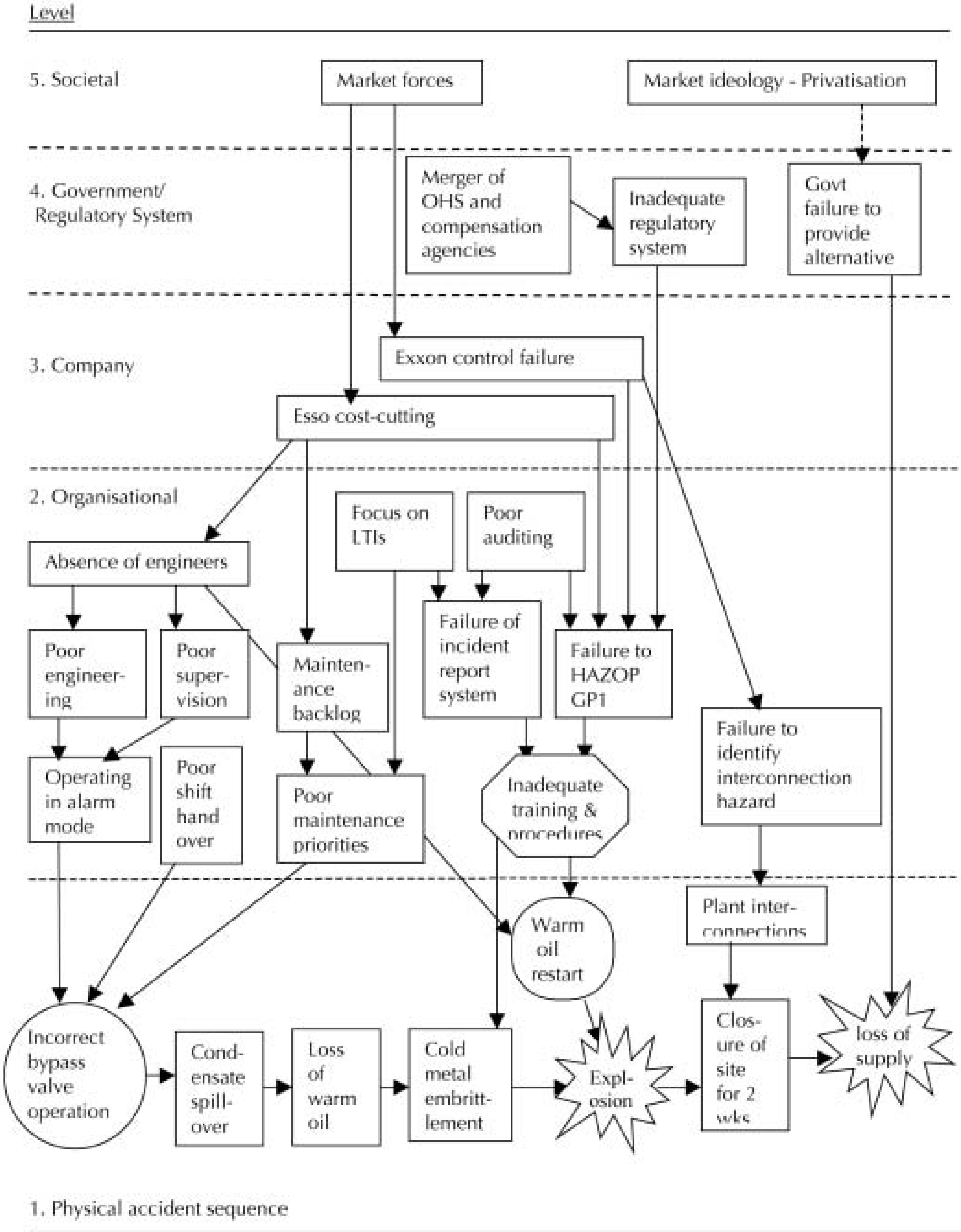


Figure 1 - AcciMap of Esso Gas Plant Accident.

An Occupational Health & Safety Research Perspective

Jeffery L. Kohler, National Institute for Occupational Safety & Health Pittsburgh

Over the past thirty years we have witnessed a dramatic reduction in mining fatalities, injuries, and work-related diseases. These reductions represent two, three, or even ten-fold decreases from just a few decades ago. The credit for this remarkable achievement comes from many corners: research advancements; manufacturing innovations; labor and industry; mining engineering curricula that integrate health and safety practices, and stronger government regulations.

Despite these successes, data from recent years have shown limited improvement in the health and safety numbers that we use to measure our progress toward our ultimate goal of zero injuries and fatalities. This is especially troubling to all of us who believe that injury and impairment no longer need be consequences of working in the mines.

The challenge before us is clear, and many in the mining industry stand poised to accept this challenge. But exactly what path do we follow to achieve success? Perhaps there are multiple legitimate paths, and in this presentation, I will describe and illustrate one course of action, briefly summarised in five steps. First, we must accurately characterise the present circumstances in relation to safety, looking for sentinel events, and acknowledge the changes in the industry that are taking place. This characterisation will be helpful in the second step, which is to develop an understanding of the underlying causes of the problems. Next we propose very general interventions, then ascertain the barriers to these interventions. Once these are known, we execute a focused effort to develop and institute effective interventions. The fifth step is to study and quantify intervention effectiveness so that resources are allocated in a fashion to effect the greatest health and safety benefits.

This approach is not particularly novel, and only takes on value when specific details are added. Although my view of this is strongly influenced by mining safety and health issues in the United States, many of the lessons learned there are transferable, and indeed, many of the lessons learned in Australia and other mining countries have been successfully applied to improve health and safety in the U.S. The global nature of modern minerals production offers new and powerful opportunities to solve old problems and prevent new ones. Goals of this presentation are to identify specific examples that can be useful as we accept this new challenge, and to identify collaborative opportunities for achieving the vision of eliminating occupational injuries and illnesses from the workplace.

Health Reporting in a Multinational Resources Company

Dr P Shanahan, BHP BILLITON

BHP Billiton is the world's largest diversified resources company with more than 35,000 employees and operations on every continent. The scope of business apart from significant mining operations includes petroleum, with offshore facilities and onshore gas production, and a range of refinery and smelting operations for aluminium, chrome, manganese and nickel. Mining operations are focused on coal, iron ore, copper, chrome, bauxite, manganese, nickel, mineral sands and diamonds. Consequently a vast range of potential adverse health exposures exist throughout the company with operations situated in regulatory environments that vary considerably.

Corporate reporting for health was significantly upgraded for BHP Billiton during the full year 2003. A primary purpose for corporate reporting is to track performance towards targets for health. Health targets for BHP Billiton are strongly focused on lead indicators of exposure with secondary targets for lag indicators of occupational illness prevalence and incidence. Therefore, to assist meaningful corporate reporting on health indices it was necessary to develop and implement standardised occupational exposure limits. These standards also include direction on sampling and analysis processes to ensure validation of data.

The integration of health reporting was aligned with existing HSEC processes. Monthly reporting occurs for safety performance throughout the company and for higher level incidents relating to health, environment and community. The process of reporting has been set up on a company wide internet based program known as First Priority Enterprise. It was determined that health reporting should be conducted on a six monthly basis. At this level it would be possible to capture evolving issues in health during the reporting year, particularly in relation to shorter latency conditions. In terms of data required there will be a transitional period of building a higher level of detail and sophistication over a two year period, particularly in relation to occupational hygiene data. This will allow sites to adequately capture and organise data into a more formalised structure across the company. The aim is for all operations to collect occupational hygiene data through homogeneous exposure groups.

The data being collected is aligned to the company health targets. Currently these targets are:

- All sites to complete a baseline survey on occupational exposure hazards and establish an associated monitoring and health surveillance program by 30 June 2003

- Reduction of occupational exposures below internationally accepted limits by 30 June 2004 and a 20% reduction in incidence of occupational disease by 30 June 2007.

Reporting for year 2003 has therefore focused on performance to the initial target of completion of the baseline exposure survey and medical surveillance program and also included the collection of baseline data on occupational exposure and occupational illness. Occupational exposure data will be aligned to occupational exposure limits derived from leading authorities. Significant exposures existing in the company will be further investigated through company position statements which will lead to the development of a final exposure limit based on thorough review of available literature from global authorities. Reporting of occupational exposures is more heavily weighted toward leading indicators as follows:

- Status of baseline exposure survey
- Medicals required/completed
- Employees potentially exposed > 85 dBA TWA
- Employees potentially exposed at 50 - 100% of the occupational exposure limit/up to three significant exposures involved
- Employees potentially exposed at > 100% of the occupational exposure limit/up to three significant exposures involved
- PPE compliance %/Existence of a formal PPE audit program.

Reporting of occupational illness data is focused on the major categories of illness pertaining to our operations. OSHA criteria are used as the definition for occupational illnesses. Illness data is a lag indicator. Categories reported are as follows:

- Prevalence of the specific occupational illness (Total active cases on site)
- Incidence of the specific occupational illness (New cases diagnosed during the reporting period)
- Retirements due to occupational illness.

As a consequence of data received several initiatives have been set in place. This includes direct attention to operations with specific occupational illness incidence of concern, development of a standard PPE compliance auditing guideline for use globally and work with specific operations through provision of guidance and resources to progress the baseline exposure survey.

In summary the development of meaningful corporate reporting requires a strong link for this data to defined health targets that operate throughout the company and are linked to relevant management KPI's. The data should be strongly focused on lead indicators that in particular measure exposure indices. Data must be linked to standardised measures and definitions that are used by all operations and supported by appropriate Corporate based guidelines when required. Reporting processes should be linked to systems available for other components of HSEC and periods of reporting allowing timely capture of data to initiate actions.

Health Surveillance: Past History & Future Potential

Brian Lyne, Department of Natural Resources & Mines

Executive Summary

Mine safety is about eliminating or applying appropriate controls on occupational health hazards that have the potential to cause disabling injury or illness.

A recent tripartite review of mine health surveillance in Queensland found a number of interesting opportunities to introduce a new health surveillance process suitable for use in the broad mining and quarrying industries throughout Queensland.

The paper identifies these opportunities in a clear way and provides an integrated three stage model to provide a practical direction for the future.

By working in partnership with industry stakeholders, it is anticipated that the a revised Health Surveillance Unit will assist industry in either eliminating or better controlling occupational health hazards found in mine and quarry work places.

Improved management of mine worker occupational health practices and assessments should pave the way for a quantum improvement in the future safety statistics.

Many of the large mining companies as well as the Minerals Council of Australia have recognised the importance of occupational health management and have initiated strategies and programs to achieve improved performance.

Several large mining companies have already commenced development of improved health management practices and this paper provides a possible framework to harness their collective learning and in doing so minimise wasteful duplication of effort across the industry.

By adopting this course of action it is anticipated that significant progress can been made to achieving a mining and quarrying industry that, in the future, is free from disabling occupational injury or illness.

Background

Occupational illness and disease in mineworkers has been identified as a serious problem for many centuries. Agricola (1484–1555) wrote extensively about many of the occupational health problems he had identified in the local population of mineworkers in Germany. In particular, he identified several health hazards including those caused by various respirable dusts found in mines.

Knowledge of health hazards increased slowly over the succeeding centuries and it was not until the mid 1900's that medical science could measure respirable dust levels and modern medical management systems implemented.

Health surveillance of mineworkers in Queensland was initiated in 1982 when the Queensland Coal Board issued two Health Orders under the *Coal Industry (Control) Act 1948*. In 1993 it was again upgraded and following the abolition of the Board in 1997, the health surveillance requirements for the coal industry were transferred into the coal mining legislation. With the introduction of the new *Coal Mining Safety and Health Act 1999* and the *Coal Mining Safety and Health Regulation 2001* the regulation included further changes to the *Coal Mining (Industry Employees Health Scheme) Regulation 1993* health scheme and it became the *Coal Mine Workers' Health Scheme*.

The current health surveillance program only applies in the coal industry and utilises an approved health assessment form for medical practitioners to follow which is similar to a document developed and used by the medical division of the Coal Services Pty Ltd (ex Joint Coal Board). The prime focus of the medical examinations to date has been to monitor black lung disease (pneumoconiosis), hearing loss, eyesight and fitness of mines rescue trainees.

At the same time as the new coal mining legislation was introduced in 1999, the *Mining and Quarrying Safety and Health Act 1999* was enacted and included legislative requirements for health surveillance and medical assessments. The mines and quarries were not required to report the results of medical assessments to the regulator and nor were they required to conduct medical examinations in accordance with an approved form (as is the case for the coal industry).

In 2002, a report into an operational review of the Mines Inspectorate for the period 1996/97 to 2001/02, determined that the inspectorate's role in safety was well established but its role in health was less defined. The report received ministerial endorsement in April 2002 and included a recommendation to review the future role of the regulator in relation to health surveillance during 2002/03.

A steering committee and a tripartite working group were given the task to investigate and make recommendations on future directions for the regulator. The Working Group consisted of representatives from unions, employers and inspectorate involved in the metalliferous mining and coal mining industries. The agreed common objective for the review was:

"To recommend a business model for health surveillance in Queensland in partnership with the mining industry, that will assist in the systematic identification, assessment and elimination /control of adverse occupational health risks to mine workers."

The review included investigation into current health surveillance practices in Western Australia and New South Wales. It was found that the regulator in Western Australia conducts health surveillance on all mine and quarry workers, the industry consisting of primarily metalliferous mining activities. New South Wales were found to conduct their health surveillance of coal mine workers through a private company, Coal Services Pty Ltd (previously Joint Coal Board), however no similar service was found to exist for the metalliferous and quarrying industries.

In general, the study found that the prime focus of mineworker health surveillance programs in New South Wales, Western Australia and Queensland concentrated on respiratory disease and noise-induced hearing loss.

The Working Group then sought information to confirm or indicate possible occupational illness or diseases that were currently affecting the workers in mines and quarries.

In order to achieve this objective, information from a wide range of sources was reviewed. In addition to the coal industry medical data already collected by the health surveillance unit other sources such as Workers' Compensation, the coal industry superannuation fund and records kept by an industrial organisation were reviewed. As a result of this wide review, it was apparent that the current health surveillance was not focused on current occupational health hazards affecting mine workers.

Figure 1 provides a profile of occupational injury and illness data that clearly demonstrates the current emphasis on respiratory and hearing conservation matters are relatively well controlled and other health issues have a higher incidence rate.

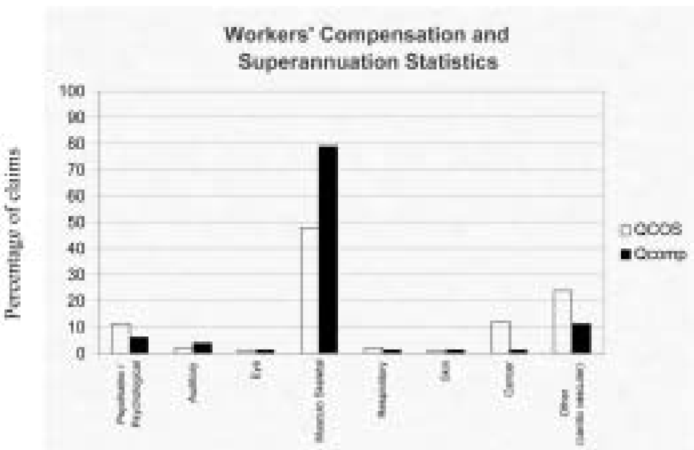


Figure 1: Comparison of workers' compensation data (percentage of total payments) against Q-COS claim numbers for specific disease groups.

Workers' Compensation data covering the entire metalliferous mining, coal mining and quarrying industries and the coal industry superannuation data were examined. The analysis indicated that the major occupational injury and disease problems in the mining industry were found to be heavily oriented towards musculoskeletal injury and psychological impairment with a relatively minor amount related to respiratory and auditory injury or illness.

In addition to these findings, a number of other important and related findings were made.

It was estimated that almost 100 percent of employees in the coal mining industry undergo the required medical examination, however less than 10 percent of the workforce suffered a compensatable injury. Anecdotal evidence was provided from two separate sources, which indicated upwards of 30 mineworkers, had their employment terminated each year due to occupational illness or injury. The current health surveillance system does not capture this type of important data. No similar data was found which would allow an estimate of the occupational injury / illness experience in the metalliferous mining and quarrying industries to be made.

Other shortcomings of the current system included that there are no records available on persons who have either "retired" from the mining industry early, had their employment terminated or changed work tasks as a result of occupational injury or illness. This was found to be a particular omission where persons had suffered from an injury or illness caused by a long-term exposure to an occupational health hazard such as whole body vibration or high blood lead levels.

A total of 21 recommendations were made in the report and include:

- Replacement of the existing Coal Mine Workers' Health Scheme with a new Health Surveillance Unit (HSU) that meets the needs of the coal mining, metalliferous mining and quarrying industries in Queensland
- The HSU to be based in Brisbane
- The principal role of the HSU to be the collection, analysis and reporting of adverse health assessment data
- The HSU to be part of the Mining Inspectorate and communicate its findings to industry for preventive action and to facilitate epidemiological and other research where appropriate
- Provisions to be included in both mining acts and subordinate legislation to permit the proper functioning of the health surveillance process
- Identification of duties of key personnel including "Site Senior Executives" and "Employers", to ensure appropriate health surveillance of workers and the ongoing control of risk of disabling injury or disease
- Appointment of medical practitioners to be known as "Appointed Medical Officers" whose duties will be defined by regulation
- Industry operators to develop a protocol for large operators to share information on occupational health risks with small miners and contractors
- Establishment of medical practitioner support for the new HSU, initially by a part-time occupational physician and, on a permanent part-time basis, a panel of medical practitioners with experience in the mining and quarrying industries.

In order to meet the needs of the broad mining and quarrying industries, a new model for the development of health assessments, application of the model and finally the implementation of a new health surveillance unit were developed. The entire process is generally compatible with the current legislation related to both the mining and quarrying industry and the coal industry.

Proposed Model for Health Assessment Development

In order to implement a holistic program, it was determined that each mine and quarry develop and implement an occupational health management process as part of the mine safety management system. This would be done by a process identified in Figure 2. The health hazards associated with each work task would need to be identified, subjected to a risk assessment and effective controls put in place.

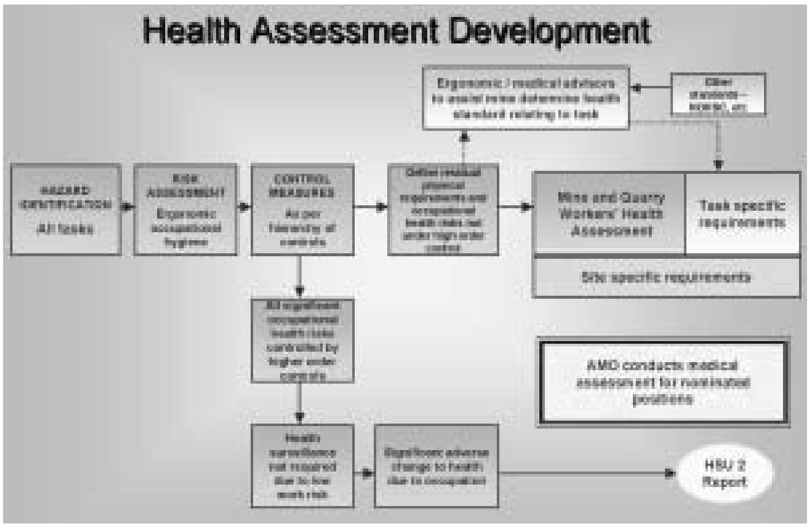


Figure 2: Steps in development of a Health Assessment Program.

Where all significant health hazards associated with the work task were able to be placed under high order controls the task could be identified as not requiring workers to undertake a health assessment.

For work tasks that have a residual occupational health risk that is unable to be placed under a high order control, the worker would be required to undergo the baseline "Mine and Quarry Workers' Health Assessment"' plus any task or site specific assessments.

Mine & Quarry Workers' Health Assessment Form

The Working Group determined that the information contained in the current reports from the Coal Mine Workers' Health Scheme should be kept as a resource for future analysis. The existing approved form used for the Coal Mine Workers' Health Scheme was found to need modification to meet the needs of the new mining and quarrying industry health surveillance process. The modified form includes best practice procedures from similar forms used in New South Wales and Western Australia.

The Working Group supported the adoption of a similar process to that used in Western Australia for determining if a chest x-ray should be included as part of the assessment. This system identifies those who are likely to have had significant exposure to pneumoconiosis-producing dusts in the past, or are entering a job with a risk for such exposure in the future, so that a chest x-ray can be included in their assessment. Otherwise, the chest x-ray will not be a mandatory requirement for health surveillance. This requirement for chest x-rays is also similar to the current requirement in the Queensland coal industry.

An interesting addition to the previous health assessment process is the proposed inclusion of the graphical representation of trends in specific health risks. It is anticipated that this information be provided to both the employer and the employee with the aim of encouraging proactive efforts from both parties to maintain good health. A typical trend graph is found in the HSU 2 report (Appendix 2).

Additional Task & Site Specific Health Requirements

There are tasks at mines and quarries that will have specific health requirements identified in order for the task to be completed safely. These may require additional assessments to the baseline medical assessment to be made.

Task Specific Requirements

Task specific issues occur where there is exposure to a specific hazard while carrying out a task that is not common across the whole workforce. Exposure of a dozer driver to significant whole body vibration, or exposure of a smelter worker to lead, are two examples of task specific exposures that could indicate a need for additional components to the health surveillance process. This might mean, in the first example, that the doctor would need to make a more thorough assessment of areas likely to be affected by whole body vibration, such as the lumbar spine. Where there is additional risk from exposure to a designated hazardous substance, as in the second example, the requirements of the National Occupational Health and Safety Commission's Health Surveillance Guidelines, including biological monitoring where appropriate, would become part of the health surveillance process.

The frequency of task specific assessments might vary from the normal health assessment, usually being more frequent, especially where biological monitoring is required.

Underground mining carries with it additional risks from catastrophic events such as fires, explosions and the development of dangerous gas levels. In the event of such an occurrence, the worker is required to escape as rapidly as possible, often on foot via ladders and steep passageways. As a result, a task-specific assessment may need to ascertain that the worker's level of physical fitness is sufficient to allow the mineworker to escape from the mine or to a place of safety. These specific requirements may be included under this section.

Other risks, such as those from exposure to physical hazards such as heat, noise or various forms of radiation, or biomechanical, biological or psychological hazards may, once identified as significant, also be the subject of additional components to the health surveillance for individuals or work groups. Where possible, the use of standardised health surveillance procedures from competent authorities should be endorsed by a panel of recognised specialists.

Site Specific Requirements

The Working Group accepted that it remains the prerogative of the SSE/employer to set certain health standards for their workforce over and above those required by the mandatory health surveillance process. The additional health assessment requirements must relate to the management of hazards at the mine. This may result from the geographic location of the mine, other conditions specific to that mine site, or from a procedure on an issue such as drug and alcohol testing.

These site-specific health requirements will be additional to the normal health surveillance assessment required for that particular mine or quarry site, though results will not generally be reportable to the regulator.

Application of the Health Assessment Process

All mine and quarry workers, who are to undertake tasks where there is an occupational health risk present that is not under a high-order control and which could reasonably be expected to cause a disabling injury or disease, will need to undergo a medical assessment. As a minimum, this will be in accordance with the Mine and Quarry Workers' Health Assessment Form. Task and site specific occupational health assessments will be conducted at a frequency determined by the risk level or the medical condition of the worker.

The critical link between the operations at a mine and the Health Surveillance Unit is shown in Figure 3 and provides a schematic flow chart of how the health assessment process would be implemented into the mining industry. The flow chart also indicates the areas where reports will be required by the regulator (Health Surveillance Unit).

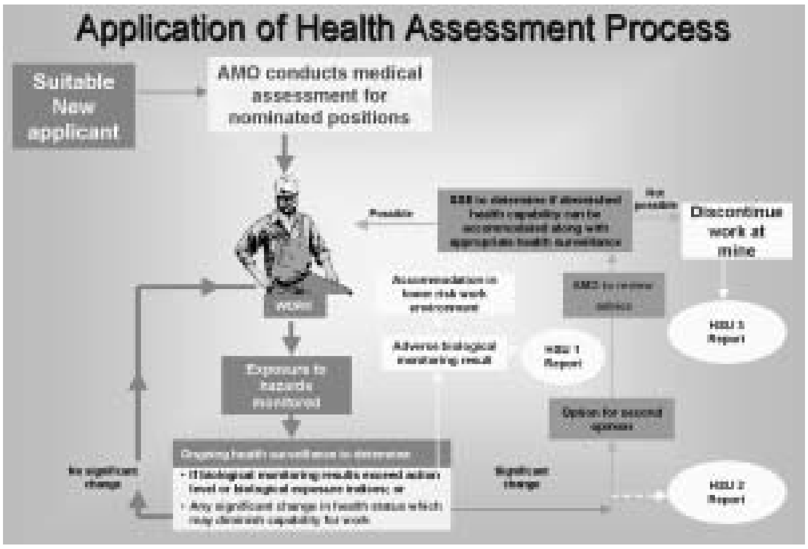


Figure 3: The medical assessment path for all mine and quarry workers from the time of application to cessation of duties at a mine or quarry.

Having developed a relevant health assessment standard suitable for the work tasks at a mine, the SSE would be required to ensure that all medical assessments for either new applicants or existing workers are conducted in accordance with the mine standard.

Medical Assessments

It will be mandatory that, for the system to be effective, mine and quarry workers must make themselves available to undergo a medical assessment and also agree for the data to be analysed by the regulator (Health Surveillance Unit).

In the event that the assessment reveals a level of diminished health or physical capability, the medical summary report will be brought to the attention of the SSE who will determine if the person's diminished capability can be accommodated at the mine. The accommodation may include changes to the workplace, equipment or work design, appropriate health surveillance programs or limitations of the worker's activities being put in place.

Workplace Hazard Exposure Monitoring

It is the responsibility of the SSE to ensure that the mine or quarry regularly monitors the level of occupational health hazards workers are exposed to in the workplace.

Ongoing Medical Assessments

Ongoing medical assessments must be made at a frequency related to the potential health risk to the worker. The frequency should be such that the medical assessments are able to indicate any adverse trends in a person's health before a significant adverse change is found that requires their removal from the task.

The ongoing medical assessments have two separate elements, each of which may have different assessment cycle times:

1. The first type of assessment is to monitor exposure to hazardous agents through the use of biological monitoring or biological effect monitoring. In the event that a significant adverse result is found a HSU 1 report (appendix 1) must be prepared and submitted.

2. The second is for other significant changes to occupational health. In the event of a significant adverse change in health being confirmed, a HSU 2 report (appendix 2) would need to be prepared and submitted. Should the adverse change be of a level such that the worker may need to change duties at the mine, the worker must be given the opportunity to seek and obtain a second medical opinion. The second opinion must then be given to the mine AMO who must consider the second medical opinion before making a final report to the worker and the SSE.

Accommodation of Diminished Work Capability

Where an adverse biological monitoring result or a significant change in health has been identified and causes a diminished capability to work, the SSE will need to determine if and how other workplace arrangements can be made to accommodate the changed health status of the mine or quarry worker.

Where the SSE determines that accommodation is possible by changing duties on either a temporary or permanent arrangement, the worker must be assessed and confirmed as physically and psychologically able to undertake the new task with an acceptable level of risk.

Similarly, the SSE must ensure that duties given to accommodate injured workers during their rehabilitation program do not pose an unacceptable risk to the workers' health.

Should the SSE determine that accommodation of the person's diminished health capability is not possible, the SSE must ensure that appropriate action is taken and a HSU 3 report is prepared and submitted.

Medical Reports to the Health Surveillance Unit

Instead of the current system where all mineworker medical assessment reports are sent to the current HSU, only three types of report will be required from operating mines and Appointed Medical Officers.

The proposed three circumstances requiring reporting to the HSU are:

HSU 1 – Where there has been an adverse biological monitoring or biological effect monitoring result (that is, one that exceeds the action/alert level).

HSU 2 – Where the health surveillance assessment detects significant deterioration in an existing worker's occupational health, requiring the SSE to accommodate the change in the work capabilities of the worker.

HSU 3 – Where the health surveillance process detects significant deterioration in an existing worker's health or biological monitoring result and the SSE determines that the worker's diminished capability cannot be accommodated at the mine. The worker is to be removed from those activities.

Proposed Health Surveillance Model: The Health Surveillance Unit

Research conducted as part of this review indicated that the majority of coal mineworkers were able to complete their working careers without suffering a permanently disabling injury. It is anticipated that the mining and quarrying industries would have a similar injury profile.

By focussing only on the adverse health monitoring results, the current resource allocation of two staff members in the Health Surveillance Unit is expected to be adequate to capture, analyse and report on behalf of the full Queensland mining and quarrying industry.

Due to the large financial resources potentially required to address many of the health hazards in the workplace, some of which were identified as needing research, the Working Group supported the proposal that, in the first instance, the major effort should focus on the larger organisations, with the lessons learnt then made available to smaller operators.

Should the need arise for the HSU to participate in epidemiological research into the health of mineworkers this could take place after the major health risks have been brought under control.

The objective, in the case of mineworkers, would be to build up a picture of the ongoing health of the workers over the longer term, to identify disease trends that point to risks that lead to gradual deterioration in health or to disease with longer latency, such as various cancers, respiratory, cardiovascular or neurological disorders. One example would be to determine the risk of cardiac disease in miners exposed to diesel particulates. The focus of this type of study is prevention. Once a particular work exposure is identified as a risk for a particular disease, risk-reduction strategies can be developed that can be adopted across the industry as a whole. It is anticipated that studies of this nature will often link to other studies in other states and countries such as the USA.

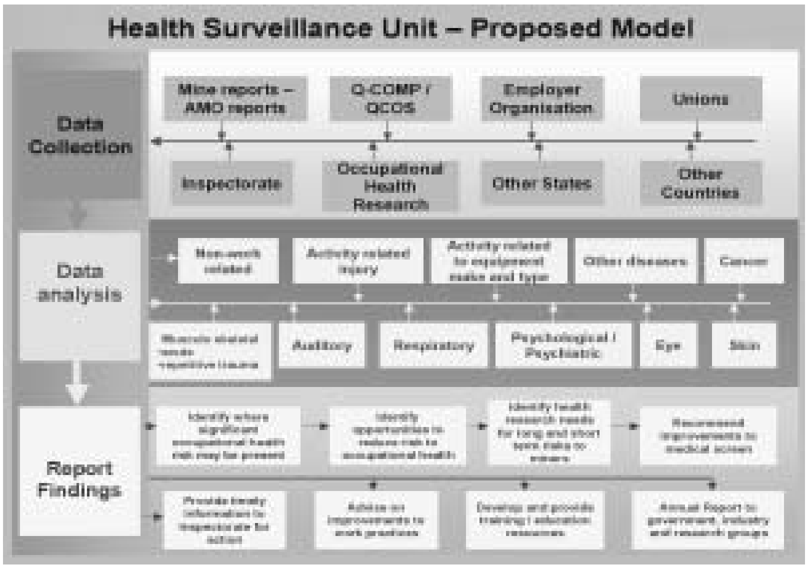
The Working Group accepted that to address this objective, the current surveillance process that provides data from coal mineworkers would need to be extended to cover the total mining industry.

Role, Structure & Function

The role, structure and functions of the HSU were refined during the extensive consultation program conducted. There are three basic elements to the activities required of the HSU as indicated in Figure 4.

1. Data Collection
2. Data Analysis; and
3. Report Findings.

Figure 4: Proposed Model of the Health Surveillance Unit.



Role

The role of the HSU is to champion the issue of occupational health for all mine and quarry workers in Queensland. Its role is not to interfere with employers who act responsibly in ensuring their employees do not suffer any disabling occupational injury or disease.

Its role is, however, to identify activities or occupations at mine and quarry sites where there is firm evidence that occupational health hazards exist and are not adequately controlled. It is the role of the HSU to advise the inspectorate who in turn will ensure that the SSEs respond appropriately to minimise the risk to the health of workers at the mine or quarry.

It is the role of the HSU to establish and maintain contact with other professional bodies and benchmark best practice against HSU standards and practices.

The HSU will need to collect all available information in compliance with the Privacy Principles on mineworker health and conduct statistical analysis on the data and report on its findings.

As a minimum, the data analysis will categorise the data into the following classifications:

- Non work-related injury
- Activity-related injury
- Injury related to equipment type or manufacturer
- Cancer
- Musculoskeletal disorders caused by both acute and repetitive trauma
- Auditory disorders
- Respiratory disorders
- Psychological/psychiatric impairment
- Eye disorders
- Skin disorders
- Other diseases.

The HSU will be responsible for identifying where improvements can be made to the health assessment form and also where research into health matters may be required.

Structure

A very simple organisational structure is proposed. The HSU should be a stand-alone unit within Safety and Health, be separate from the inspectorate and have its own budget. The Unit should have a manager, one data supervisor and part-time support from a statistician and an advisory panel of occupational physicians.

In general terms, the HSU manager will liaise with industry stakeholders and AMOs, ensure that privacy protocols are maintained, implement training as required, develop and provide training resources and provide reports as required.

The Data Supervisor will ensure that data is collected and analysed in accordance with Australian standards, maintain regular contact with suppliers of data, conduct regular checks on the integrity of the data and ensure data entry is up to date. The Data Supervisor will also ensure that the strict privacy protocols are maintained.

Part-time assistance from the Safety and Health Statistician will also be required, who will conduct or oversee the analysis of the data and ensure it is done in compliance with Australian Standard 1885.1 (1990).

Functions

In fulfilling its role to the mining industry, the HSU will have the following functions:

- Be a centre of excellence where high ethical standards are maintained with special emphasis on privacy matters
- Collect medical data relevant to the occupational health of mine and quarry workers and comply with privacy policy requirements. The data sources are detailed elsewhere in this report
- Analyse information received in a manner which is relevant to the health needs of mine and quarry workers
- Report results of data analysis
- Advise the inspectorate on activities or other matters where significant health risks have been identified
- Develop training resources and facilitate training in occupational health
- Provide statistical data to support research
- Participate in epidemiological and occupational health benchmarking studies with other research groups, states and/or countries.

It is anticipated that the proposed new health surveillance model should be able to be implemented with two staff members and only a moderate increase in the budget allocation that exists for the current Coal Mine Workers' Health Scheme. The significant change from the current system being that under the new process, only persons whose occupational health has been adversely affected will be reported to the new HSU. All other medical records will be kept by the Appointed Medical Officers and be available to the HSU, possibly by electronic transfer/interrogation methods.

Opportunities for the Future

The Working Group members were unanimous in their desire to see mine operators and the regulator work in partnership to achieve a well-focused health surveillance program for all mine and quarry workers. By sharing information small and large operators should be able to improve current practices with a minimum of disruption and cost to the business. It is confidently anticipated that such a partnership will result in worker health and safety being enhanced.

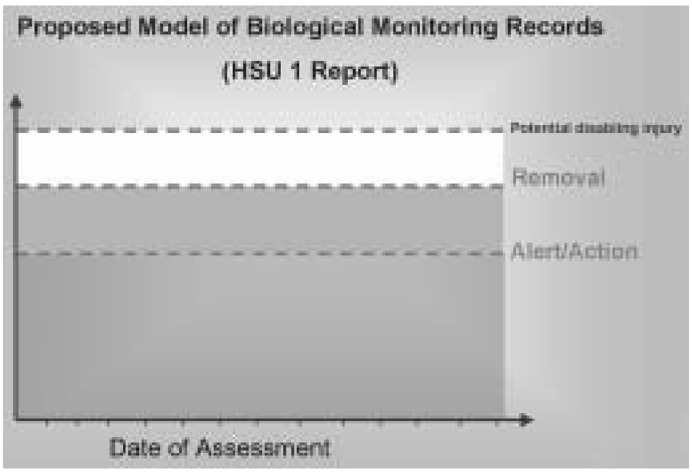
In addition, opportunities for further research have been identified such as developing electronic data management systems and access a wider range of health data from sources not currently utilised in either Queensland or other states. This will require detailed attention with respect to the setting up of robust systems to ensure the Privacy Policy is implemented and complied with at all times.

Conclusion

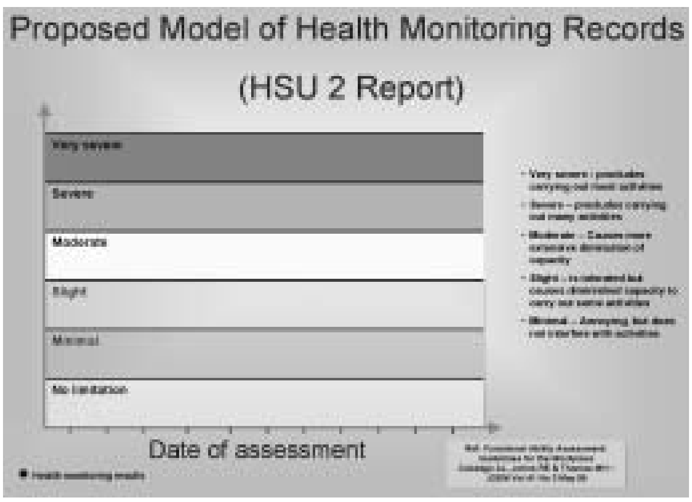
The proposed health surveillance model is consistent with the direction that several large mining houses have now embarked upon. The Minerals Council of Australia have indicated that they are actively developing an Australia-wide health surveillance model for the mining industry and have received two presentations on the proposed Queensland model as set down in the report. The NSW Mine Safety Council and Coal Services Pty Ltd (Previously Joint Coal Board) have also developed a strong interest in the proposed health surveillance system for Queensland after having received separate presentations on two occasions.

The opportunities are there to identify, control or eliminate the currently known occupational health risks. It now needs the commitment of all stakeholders to ensure that the mining and quarrying industry workers benefit from well focused health surveillance programs.

Appendix 1



Appendix 2



A Study of the Health & Safety aspects of Shiftwork & Rosters at the PCML

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Abstract

This paper reports the conclusions of a study that was undertaken to assess the safety risk and health aspects of shiftwork and rosters at the Pasminco Century Mine Limited (PCML). PCML has guidelines in place to manage fatigue and wished to assess their effectiveness and the need for any changes. In part, this recognition was catalysed by the paucity of relevant data and studies on shiftwork and commute rosters in the metalliferous mining industry.

The health and safety performance at PCML is among the best in the Australian Mining Industry. The system for managing fatigue is an integral part of the overall health and safety management system at PCML.

In conclusion, the data show that sleep quality and quantity does not deteriorate over multiple 24-hour periods, and that a commute workplace that supports and promotes a recovery environment will be less impacted by fatigue than a community based workplace where the recovery off-shift may be more difficult and may lead to an accumulated sleep debt.

In addition, there is no evidence from this study to indicate that fatigue as a result of the work rosters and shift cycles worked is a significant contributor to accidents and incidents at PCML.

Introduction

The study was commissioned by PCML to evaluate the effectiveness of the fatigue management initiatives that have been implemented at the Mine. Unlike other studies this project focuses purely on the safety risk and health aspects of fatigue whilst employees are on site. The study does not cover social and economic aspects of shiftwork and roster influences off site or in the domestic setting.

This distinction was principally made because PCML, in common with all fly in fly out operations has a strong influence over site conditions both during working hours and during rest and recreation between shifts. This degree of control obviously does not exist with a conventional residential based workforce.

Overview of Century Operation

PCML is one of the largest zinc mines in the world, producing 880,000 tonnes of zinc concentrate and 70,000 tonnes of lead concentrate annually.

Century's operations comprise two sites being the open-cut mine site located at Lawn Hill and the port site at Karumba, both in north west Queensland, Australia. Mining zinc, lead and silver, the open cut mine is expected to operate until 2018.

PCML was the recipient of last years MINEX Award presented by the Minerals Council of Australia in recognition of excellence in the field of safety and health in the mining industry. The fatigue management initiatives in place at Century were recognised as providing an industry benchmark for best practice.

Commute Roster Arrangements

Century employs approximately 570 personnel on a fly-in, fly-out basis who commute from a number of regional centres in far north Queensland. These include Townsville, Mt Isa, Normanton, Doomadgee, Burketown and Mornington Island.

There are four main roster cycles of twelve-hour shifts that are worked at Century Mine. These rosters reflect the different operational requirements at the Sites. These include:

- A six week cycle of five days on followed by two days off for four weeks, followed by seven days on and then seven days off
- 9/5 roster – nine days on followed by five days off (providing four day overlap with opposite shift within two week period)
- 14/7 – fourteen days on followed by seven days off (providing one week overlap with another shift)
- 21/7- twenty-one days on followed by seven days off (one week on day shift followed by two weeks on night shift, or two weeks on day shift followed by one week on night shift).

Personnel employed at the Port facility at Karumba live in the town in purpose built rental accommodation and being residential, their responses are not included in this paper but were included in the overall study.

Lifestyle at Darimah Village, Century Mine

The lifestyle at Century promotes a well-balanced approach to food, diet, exercise, sleep and social activities. All personnel live at the Darimah Village, and are provided with the following facilities:

- Air-conditioned rooms with pull-down shutters to exclude noise and light
- Room cleaning service with full linen change once a week
- Access to free laundry facilities
- Sporting facilities including 25 metre heated swimming pool, gymnasium with state-of-the-art equipment, tennis/basketball/netball court, indoor cricket pitch, oval for touch rugby, golf, walking tracks, bicycles and a yoga space
- Exercise instructor who is also responsible for maintaining the sporting facilities
- Recreation facilities including TV rooms, pool tables, darts, movie channels, Bacchus Club and Century Community Club social nights
- Dining facilities and menu options that promote a healthy and balanced diet that are also approved by a qualified dietician (and endorsed by the health promotion character 'Ernie')
- Two bars with limited bar hours and restricted purchase of 'take-away' alcohol
- Shop, phones in rooms, public phones and mobile phone coverage
- Outdoor barbeque and recreation area located away from residential area
- Village Medical Clinic and on-site Medical Centre staffed by Registered Nurses
- Village noise abatement policy that restricts noise after 9.30pm at night and 9.30am in the morning
- Fatigue Management Guidelines
- 'Working in the Heat' Guidelines and scheduled monitoring programme
- Workplace Drug and Alcohol Policy and procedures that promote education and awareness programmes including self-testing, and monitoring via random testing
- Transport to and from the Village, and chartered aircraft to move personnel to and from the operating sites
- Access to a subsidised Employee Assistance Programme.

Strategic Development of PCML Fatigue Management Guidelines

Most of the initiatives and facilities listed above were adopted during the start-up of the PCML in November 2000. Pasminco and their contractors recognised that they need to continually evaluate shiftwork and rosters to ensure that the variables that may contribute to fatigue were identified, and the risk of fatigue minimised and/or mitigated.

In early May 2001, a number of workshops were held on site with supervisory and operational personnel to review current arrangements with regard to shiftwork and rosters, and identify any issues with regard to fatigue.

The Workshops looked at:

- What is fatigue and contributing factors
- Standards and Legislation
- What's in place now
- Latest fatigue management approaches
- Management Plan framework
- Current rosters and shift arrangements
- Issues emerging.

The workshop participants identified the critical work related variables that may contribute to someone suffering from fatigue, these include:

- Work schedules and shift rotations eg. Night shift
- Type of work being carried out eg. Physically demanding, mentally demanding, monotonous, repetitive types of work
- Work environment eg. Exposure to noise, heat, dust etc.

An extension of this assessment was to 'risk rate' various roles on Site to identify those where the employee was more at risk as a result of being fatigued.

For example, in the mining area the higher risk roles were identified as follows:

ROLE	DESCRIPTION	FATIGUE RISK FACTORS PRESENT	LIKELIHOOD	CONSEQUENCE	RISK RATING
Mobile equipment operators, includes truck drivers in the Pit, transport drivers and lead truck drivers.	Responsible for operating mobile equipment such as trucks, graders, dozers, loaders, water carts and service vehicles in the Pit.	• Monotonous • Duration of work (12 hours) • Roster length (3:1) • Shift work • Working in isolation (transport truck drivers)	Almost Certain	Catastrophic	High
Non-mobile equipment operators, includes drill operations in the Pit.	Responsible for operating non mobile equipment such as drills, shovels, excavators in the Pit.	• Duration of work (12 hours) • Roster length (3:1) • Shift work	Possible	Minor	Moderate
Blast crew and cable crew in the Pit.	Responsible for charging drill holes with explosives and tying in shots. Cable crew responsible for laying and moving of heavy duty 11kV electric cable.	• Physically demanding • Duration of work (12 hours) • Roster length (3:1) • Night shift work (cable crew) • Extreme work environment (heat and humidity)	Almost Certain	Catastrophic	High

For the higher risk roles, such as those described above, a number of additional fatigue management opportunities were identified and implemented. These include:

- Controlled shift length and roster design (including rotating shift cycles) eg. Minimum rest breaks between shifts; Maximum shift length; restricted roster length and hours per week (*Hours of Work and Rostered Time Policy*)
- Access to self-select work breaks via the mobile equipment dispatch system in each truck
- One-on-one interview before commencing night shift for the first time, including the requirement to complete a Fatigue Management Questionnaire to assess experience with commute rosters and shiftwork.

The workshops also identified opportunities to better manage fatigue largely through educating and empowerment of personnel to improve self-detection and response to fatigue symptoms, as well as an understanding of practices to avoid the onset of fatigue. Some of the improvements were:

- Provision of information and education regarding fatigue management as part of the General Induction including presentation, booklet, and site specific video
- Return from R&R and tool box presentations on diet, exercise and lifestyle choices
- Posting of 'Stay alert, Stay safe' fatigue management posters in all rooms
- Evaluating the need to carry out non-standard work at night eg. One-off or non-routine jobs carried out during day
- Job or task specific fatigue management plan eg. Confined Space Entry in summer
- Determining requirements for stand-by and on-call duty in addition to normal role eg. Rotate through a team/crew.

Evaluation of Fatigue Management in Relation to Shiftwork & Commute Rosters

The PCML Fatigue Management Guidelines address all the major potential issues identified in the technical literature. The Guidelines will be extended to include the synergistic effects of heat and fatigue in the future.

The Study indicates that there is good evidence to indicate that in general the Fatigue Management Guidelines are properly implemented across the site. There is some comment that there may be a need to be a reinvigoration of the process in some work areas.

Effectiveness of Fatigue Management

Accident And Injury Statistics

Century currently has a Lost Time Injury frequency rate of 0.5 per million exposure hours. All medically treatable incidents are logged in the ACCstat database together with information on when the incident occurred, time of day and day into roster.

Figure 1 outlines the relative frequency of accidents and incidents over the 12-hour day and 12-hour night shift for workers who work both day and night shifts.

The data indicate that there is no clear increase in the frequency of accidents or incidents relative to the number of hours spent at work as is predicted by the literature.

Figure 2 repeats this analysis for number of days into roster for the 28-day roster cycle (three weeks on shift; one weeks rest and relaxation). For comparison the predicted increased relative risk values from the literature (Folkard , 2002) and a US mining study (Wagner, 1988) are shown.

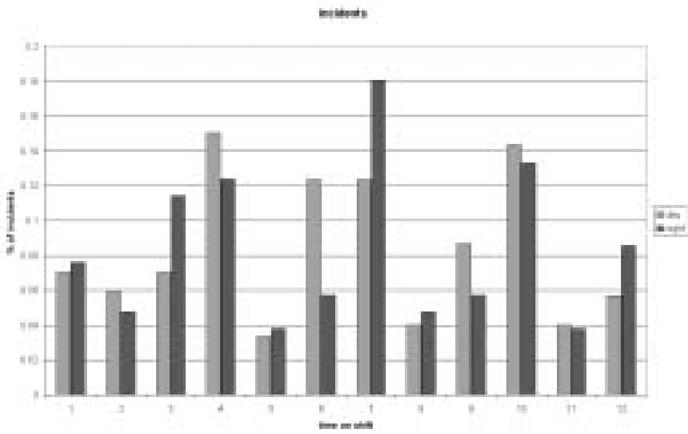

Figure 1: Relative frequency of all incidents for shift workers.

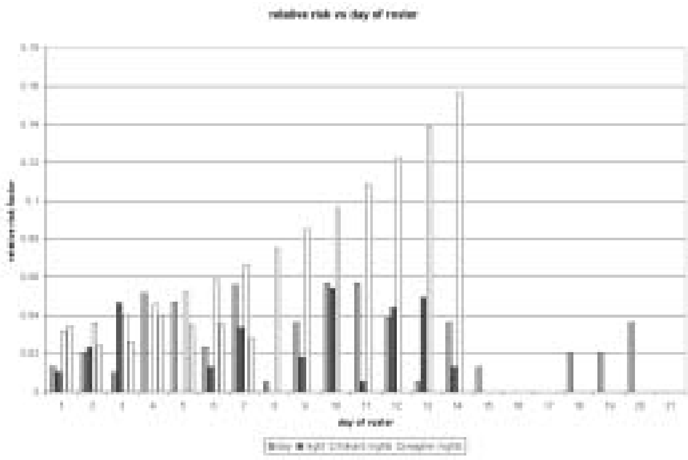

Figure 2: Analysis of incidents against day of roster for 28-day roster cycle.

The data from Century and the US study do not conform to the standard literature predictions. Similar data was obtained from workers on the 21 day roster cycle.

Analysis of Self-select Breaks

All operators of mobile equipment in the Pit can request to have an unscheduled break that is managed via the on-board truck computer system. This break is called a Code 40 self-select break.

The Code 40 data was analysed in an effort to establish any temporal trends.

The data would seem to indicate that the greatest percentage of Code 40 breaks are taken on the first few night shifts.

The data also show that compared to the first two night shifts, there is no significant increase in the number of Code 40 breaks taken as the number of shifts increases. This absence of any trend towards taking an increasing number breaks would suggest that fatigue is not incremental or carried over with the number of night shifts worked.

This is consistent with previous studies in the off-shore oil industry where personnel actually sleep better once they are in the pattern of sleeping for night shift.

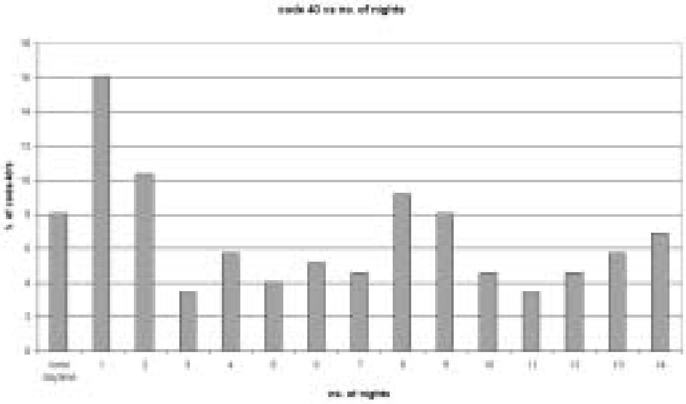

Figure 3: Code 40 breaks taken as a percentage of total number of personnel on night shift.

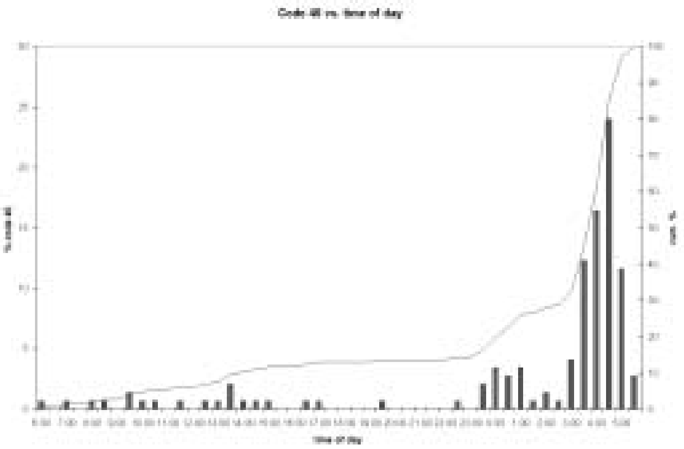

Figure 4: Code 40 break as a function of time of day.

Figure 4 indicates that the self-select breaks are mainly taken between 3am and 5am.

This graph is a classic reflection of the influence of circadian rhythm, experienced as a dip in alertness between 3am and 5am. It also reinforces the validity of the data as a true reflection of the reporting of the breaks.

The widely documented circadian 'afternoon' dip (in alertness) would appear to be masked by the scheduled meal break that is taken by all operators so that blasting can be carried out.

Self Evaluation Questionnaires

The standard Survey of Shift workers (SOS) (Folkard, 1995) was handed out to the workforce of 570 and 240 were returned. Personnel were asked to subjectively rate a wide range of issues that may relate to shift work as well as specify their sleep patterns both at home and at work under the various shift patterns.

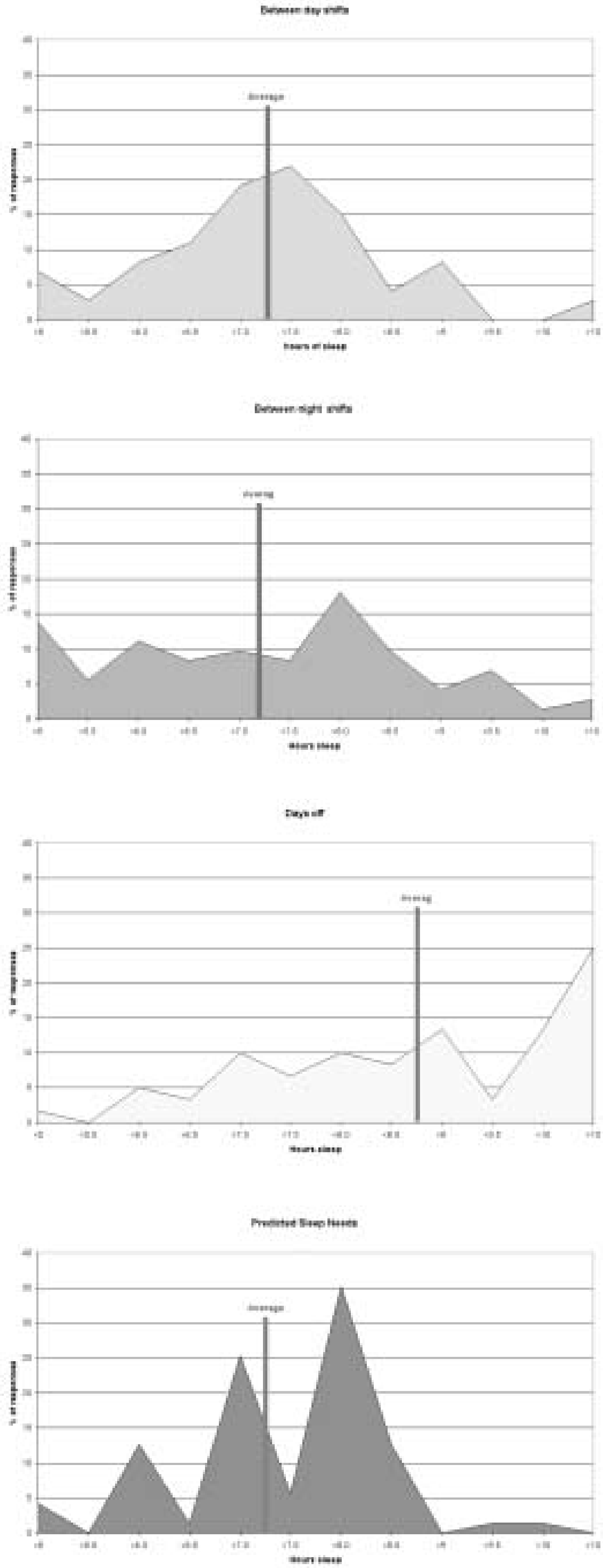

Figure 6: Distribution of hours of sleep for between day shifts, between night shifts, days off and predicted sleep needs.

These data indicate that the average amount of sleep obtained does not vary between day shifts and night shifts though the standard deviation does increase. This indicates that some people sleep better on night shift and some sleep worse.

Sleep And Alertness Logs

Sleep and alertness logs, as used in the ACARP funded research project 'Development of a risk management tool for shiftwork in the mining industry' (Bofinger et al 2002), were distributed to the workforce. A relatively small number were returned. The hours of sleep defined by these were consistent with the hours of sleep obtained from the Survey of Shift workers. It is suggested that the low return rate was in part due to the length of time (up to 28 days) that personnel would have to fill them out over.

Comparison with other Mining Studies

There are three other reported studies on sleep habits in the Australian Mining Industry:

STUDY	AUTHOR & DATE	COMMUTE OR RESIDENTIAL	SHIFT LENGTH
Burton Open Cut Coal Mine	Esson et al, 2000	Residential	Rotating 12 day and night
ACARP	Bofinger et al 2002	Mixed Residential	Rotating 12 hour day and night Rotating 8 hour day, after noon and night
Tasmanian Mining Industry	Heiler, 2002	Residential	Mixed

THIS STUDY:

Century	2003	Commute	Rotating 12 day and night

These studies report sleep habits in varying ways. Figure 7 compares the PCML average hours of sleep during days on shift with the ACARP and Burton studies.

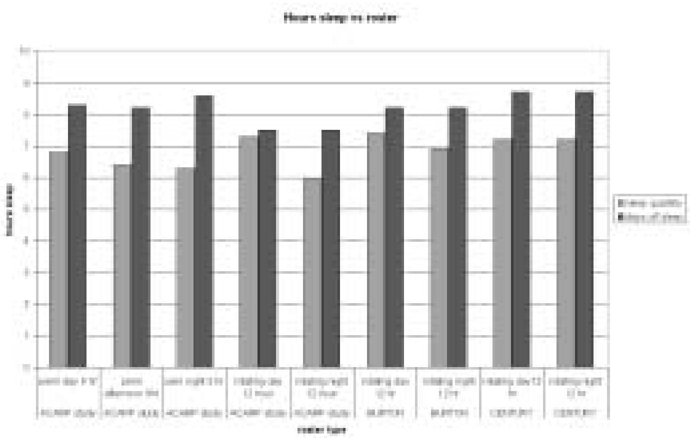

Figure 7: Average hours of sleep comparison for three studies.

Generally, personnel at Century average over seven hours sleep between shifts, which is amongst the best reported. This result would suggest that the controlled sleep environment (commute roster) does significantly influence the hours of sleep compared to a residential community based workplace.

Figure 8 reports the standard deviation of hours of sleep for the same studies.

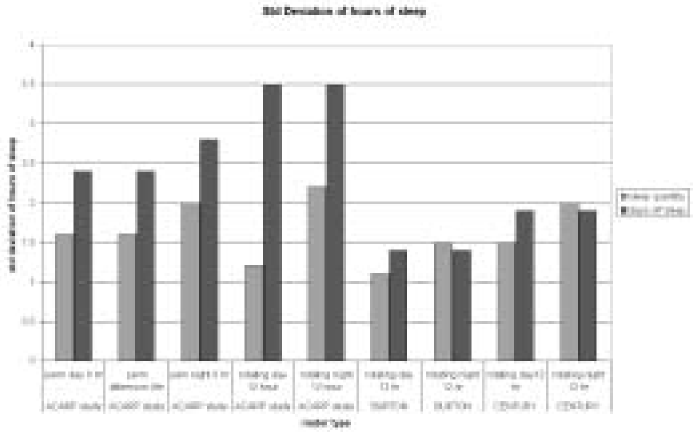

Figure 8: the standard deviation in hours of sleep while on shift for the three studies.

Consistent with the results reported above, the standard deviation for night shifts for all studies is significantly higher than on day shift. This is consistent with individual sleep patterns.

The Tasmanian study reported sleep in three groups, 5 hours, 6 - 7 hours and 8 hours or more.

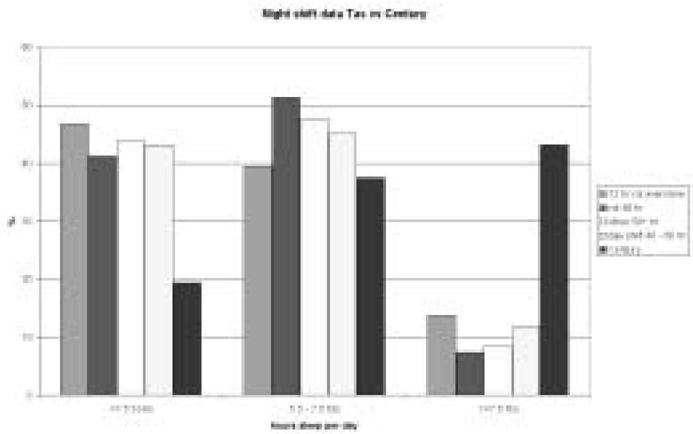

Figure 9: Night shift hours of sleep comparisons - Tasmania vs Century.

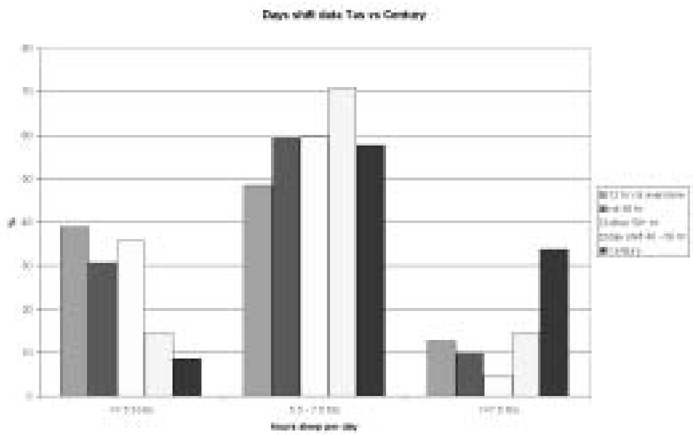

Figure 10: Day shift hours of sleep comparisons - Tasmania vs Century.

The Century data reports favourably when compared to the Tasmanian data, indicating better length of sleep, both for day and night shift (Figures 9 and 10).

The same comparisons between the Tasmanian Study and

Century were made with respect to sleep quality and similar trends were observed.

In general sleep quality after night shift is lower than after day shift, the average is still satisfactory but with a wider scatter.

These comparisons of the hours of sleep recorded by personnel working a commute roster compared to those who are residential are significant. While the influence of other variables warrants further study, this data supports a key hypothesis that the ability to manage the full 24-hour cycle in a commute operation (along with minimal domestic and other influences) is a significant positive factor in managing fatigue compared to a 'residential' community setting.

Conclusions from the Study

The core conclusion from this study is that after an initial adjustment to night shift, there is no evidence to indicate that fatigue increases. The data shows that sleep quality and quantity does not deteriorate over multiple 24-hour periods, and that a commute workplace that supports and promotes a recovery environment will be less impacted by fatigue than a community based workplace where the recovery off-shift may be more difficult and may lead to an accumulated sleep debt.

It can be concluded from the Study that there is no demonstrated link between shift cycle, rosters and accidents and incidents at PCML. The data shows a relatively even spread of accidents and incidents that does not differentiate between day shift and night shift, or the time of day or night.

A significant finding from the Study is that compared to other shift length and rotations, roster arrangements and residential operations, there is very little variation between the quantity and quality of rest between shifts recorded at work and at home. This is in direct comparison with other published studies that show wide variations between the quality and quantity of sleep recorded at work and at home. It is also of significance to note that Century employees recorded the greatest numbers of hours of rest between shifts compared with the other published studies. Again this reinforces the positive aspects of a commute environment that supports and promotes a recovery environment where each 24-hour cycle is managed.

The Study also confirms the notion that there is significant variability in quality and quantity of sleep on night shift between individuals. This is not unexpected and reinforces the place that education and awareness have in promoting self-awareness of fatigue symptoms, and promoting the understanding of practices to avoid the onset of fatigue. In addition, it qualifies the place that initiatives such as the Fatigue Management Questionnaire have in assessing and managing a workers potential to suffer from fatigue.

It can also be concluded from this Study that there may be some potential issues with fatigue on the first few night shifts, due to incomplete adaptation of circadian rhythms or wakefulness and sleep cycles. This is consistent with scientific literature on this subject, and the classical 3am – 5am alertness dip was evident. This is currently managed and monitored via the self-select work break procedure, however, there exists an opportunity to further investigate this phenomenon via continuous monitoring initiatives.

In conclusion, the observations that we have made, and the interpretations of the data that we recorded at Century may not apply elsewhere. However, it is a benchmark study into the health and safety aspects of shiftwork and commute rosters in the metalliferous mining industry, and has provided some alternative conclusions that warrant further investigation.

Acknowledgements

The authors would like to thank PCML for permission to present this paper and to all PCML employees, contractors and job contractors for participating in the study.

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Tracking Stress & Fatigue at Consolidated Rutile

Mark McGinty, Consolidated Rutile Limited

Introduction

Consolidated Rutile Limited, (CRL), introduced a Fit For Work Policy in July 1999, as per its responsibility under the new Mining and Quarrying Health and Safety Act. The system that was put in place was the Fit 2000 Fit for Duty system. Whilst the Fit 2000 system is able to record the behaviours of individuals for drug and alcohol, it is also able to provide CRL with a non-invasive process that can also monitor stress and fatigue. This paper will examine the way fatigue and stress are monitored and controlled at CRL.

For CRL, the benefits the Fit 2000 system has over other systems are:

- It is relatively easy to monitor. After the system is set up it is relatively easy to run and will only require 10 to 15 minutes per day to maintain. Managers and supervisors receive an e-mail to observe the results for their work groups
- Unlike random drug /alcohol testing, which does not detect stress or fatigue, the Fit 2000 is a holistic approach to fitness for work
- It is non-invasive and body fluids are not taken
- It is quick, at less than 30 seconds per test
- It also detects other forms of impairment such as alcohol and drugs, (legal or illicit)
- Individuals can be monitored to ensure that behaviours align with the company's Fit for Work procedure.

The initial outlay for the system was substantial, however was a one off cost, and compares favourably to random urine testing. For example: if each member of the workforce is tested three times a year the costs will be approximately $120 per person. The amortised cost of the FIT 2000 system per year equates to approximately $100 per employee with the benefit of each person being tested and a report available daily. A further benefit is that the result is available instantly compared to other testing regimes such as saliva or urine where the results may take much longer to obtain.

The FIT 2000 process involves measuring four involuntary reactions of the eye to light. By measuring these reactions against a baseline of data for each employee, the Fit 2000 can indicate whether there is an issue regarding a person being fit for work. The four involuntary reactions measured are:

- Amplitude: the time the pupil of the eye takes to react to light, (closing)
- Latency: the time the eye takes to return to normal when the light source is removed
- Pupil Diameter: the size of the pupil as measured in a controlled environment
- Saccadic Velocity: the reaction time of the eye in following a light from side to side.

Based on the sequence and the index score against each of these measures, the data can indicate that a person may have impairment, which may render them unfit for work. This may include fatigue or stress.

Fatigue

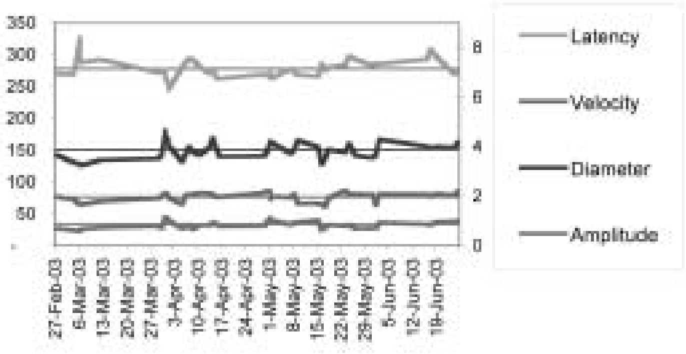
The US Army has conducted extensive trials over a four-year period to determine whether a person could be suffering from fatigue due to lack of sleep.

A recent study conducted by Russo et al (2002), using the Fit 2000, to determine whether a person is impaired as a result of fatigue, indicated that sleep depravation does effect the eye and these effects can be measured. The Fit 2000 achieves this by giving each of the involuntary eye reactions weighting. Baseline data is established for each employee and subsequent deviation from the baseline will determine whether the person is likely to be fit for work or not.

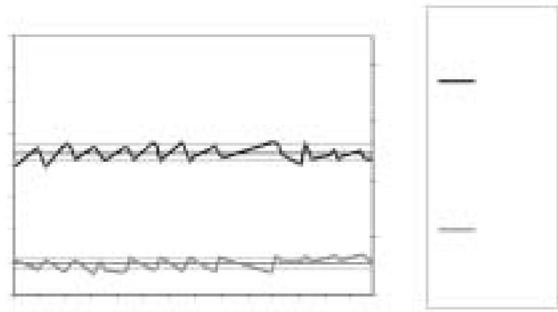
The Fit 2000 enables fatigue to be identified through a sequence or pattern such as lower saccadic velocity, enlarged latency and a slightly enlarged pupil. This pattern needs to occur over a period of time. Usually the person would need to return a "high risk" to bring them to the attention of their supervisor/manager and the person who is responsible for the data collection. This "high risk" report would be e-mailed out to the relevant supervisor for immediate action.

However, recent changes made to the report generator that is now linked to an Excel spread sheet allows us to track the sequence and patterns of individuals over a period of time. Where the data indicates that there may be a problem with an employee's sleep patterns then this can be followed up with the employee.

The following graph is indicative of an individual who returned a "high risk" for fatigue. (Note the changes around the beginning of April, end of May).



"Normal Graph"



Fatigue in all industries is a cause of injuries, which in most cases could be avoided. Research in the field of fatigue management has proven the longer a person remains in the workplace the greater risk, especially when working extended hours over days or weeks.

CRL has an "Hours of Work Policy" that limits the amount of hours an individual can remain in the workplace without a break. This policy was developed from information gathered from a number of sources, including the "Guidance Note for Management of Safety and Health Risks associated with Hours of Work Arrangements at Mining Operations" issued by the Queensland Department of Natural Resources and Mines in April 2001. The minimum required break from the workplace is 10 hours, with longer periods stipulated depending on the amount time an individual has been on the job.

Stress

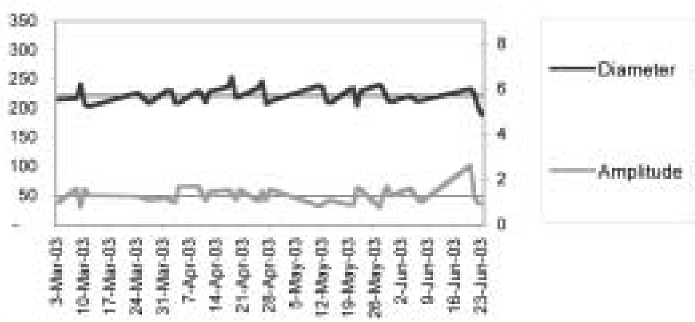
Like fatigue, stress can be a risk to all persons in the workplace. A number of factors such as organisational change, poor management practices, lack of resources, domestic problems, workload, bullying and fatigue can cause stress.

Indications of stress in an individual include absenteeism, sickness, increase in incidents and anti social behaviour all of which can lower productivity in the workplace and the team.

A comparison of results for operators at two separate mine sites indicates that the operator at one site may be experiencing more stress than the other. This is indicated by changes in the diameter and amplitude of the pupil.

The following graphs are a comparison of the operators at two mine sites.

Graph Indicating Possible Stress.



Note the difference between the amplitude and diameter of the two graphs.

CRL manages this type of stress by interviewing those affected to ascertain possible causes and to develop interventions. Interventions may include utilising our Employee Assistance Provider to support employees. One of the best techniques is to speak one on one with the individuals. This assures them that you understand that they may be experiencing difficulties and that you are concerned for their well being and safety.

Summary

Like all Fit for Work systems that are introduced, unless they are managed correctly, they will fail. Supervisors are a key element to the successful management of a fit for work system and program. Training needs to be conducted to facilitate a greater understanding of people's behaviours and signs and symptoms of fatigue and stress, in addition to the other, possibly more obvious, indicators that an individual is not fit for work. Supervisors also need to know that they have back up resources they can call on and the full support of management to make decisions regarding fit for work issues.

Most important however, using the FIT 2000 system means that the first task a person does when they enter the workplace is a safety act, to ensure they are fit to be there.

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Examining the Legal Implications of Being Fit for Work

Andrew See, Freehills

Introduction

The concept of 'being fit for work' and how fitness is to be determined has many dimensions and components[1]. At one view, it can refer to the process of pre-employment screening that is used for determining physical suitability of job applicants. In another context, it can encapsulate drug testing, fatigue policies and return to work assessments undertaken on behalf of the existing employee, all in the interests of workplace health and safety.

In the extreme it covers periodic compulsory and not necessarily random psychological and emotional quotient(EQ) testing. This is happening in the USA and has been observed here in Queensland where elements of our own Explosives Act 1999, require testing beyond physical fitness[2].

From whatever angle the issue is considered, it appears abundantly clear that as more fine tuning of the regulatory arrangements in the mining industry takes place, the reaction to such developments will cause both positive and negative responses.

One reason for this is that the practical consequences of the application of any fitness for work consideration are so impacting. In the case of a mine worker, the administration of fitness for work policies and procedures can in certain circumstances be viewed as prejudicial, determinative and life impacting. In the case of the mine operator, the process can be seen as mandatory, logical, protective and economic. This paper seeks to explore some of the legal issues through the eyes of the stakeholders.

Identifying the Concept

Earliest Beginnings

The earliest known practices of physical examination are attributed to the ancient Egyptians, but it was not until the onset of the industrial revolution in the 19th century, that some rudimentary form of occupational medicine was recognised as having taken place[3]. The emergence of workers compensation laws in Germany, followed by its introduction in the United Kingdom (1897) and later adoption in Australia and the majority of the industrialised world in the early 20th Century, created the vehicle by which workers obtained financial recompense for injuries and illnesses sustained out of or in connection with their work environment[4]. In response to the costs being borne from these new arrangements, employers began to ponder the importance of health and safety at work, causing one commentator to write in 1920:

"every applicant for work should be thoroughly examined by medical staff in order to prevent the introduction of contagious diseases into the plant and to provide for the proper selection of work for every man according to his physical and mental qualifications."[5]

Meaning of Fitness for Work

Yet there is little evidence that the concept of fitness for work has been judicially considered often since that time. One attempt was made in 1973, when the New South Wales Court of Appeal gave a meaning to the word 'fit' for the purposes of interpreting the provisions of the New South Wales Workers Compensation Act 1926. On that occasion, the Court determined that the word 'fit' should mean sufficiently fit to resume or engage in the relevant employment".[6] The court held that the term did not have to mean "absolutely fit for all forms of employment" or "absolutely fit for the employment which the worker had at the time of the injury". Thus, there was a recognition that a person may be fit for work, even though they may be suffering from some disability arising from an injury.

Some thirty years on, this question of "being fit for what?" and the meaning given to the term 'fit' still cause much consternation. Certainly, the simple response to the issue is that each case needs to be considered in light of the duties that the employee needs to perform and the injury, impairment or disability that they may suffer from. But that approach tends to oversimplify the other influences that may also affect the analysis.

Current Motivators

Some of these influences have also been identified as 'motivators' for employers, such as:

- Economic incentives for the employer relating to workers compensation, worker productivity and health insurance costs
- Regulatory requirements or guidelines issued from government agencies to minimise the risk to workers or the public
- Epidemiologic surveillance of workers for scientific and regulatory purposes; and
- Employers genuine interest in their employee's welfare[7].

Logically, there are also relevant issues that may influence the behaviour of workers and these include:-

- The right to work
- Economic needs of the worker and/or family
- Social needs of the worker; and
- Other industrial and political influences.

Let us now consider the interrelationship of some of these issues further.

Four aspects of Fitness for Work

Introduction

For the purposes of this analysis, the concept of 'fitness for work' has been broken down into four general categories of case:-

- Pre-employment screening
- Arising out of and in the course of employment
- Assessment as a consequence of accident or injury; and
- Random health testing.

At this point it is too early to consider compulsory continuous fitness testing regimes, as in the USA. It is beginning here already in special types of employment (defence forces, defence intelligence) and may become more prevalent in police and emergency recruits in the coming years. The categories of case are not mutually exclusive or exhaustive. As Figure 1 illustrates there are many aspects that make up fitness for work.

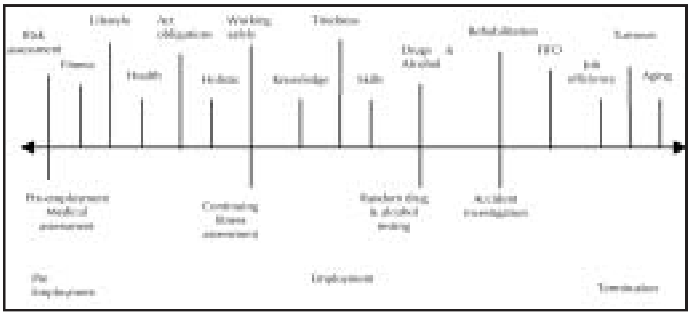

Figure 1: Issues identified within the fitness for work continuum. Source: MISHC. ACARP Scoping Study 2001.

The principal purpose for categorising into four general types of case, is to isolate some of the unique aspects pertaining to the various aspects of fitness for work. These are now addressed in turn.

Pre-employment Screening

The first category of case that we examine is that of pre-employment screening. The preparedness to participate and successfully undertake a medical examination can be a pre-requisite to the making of the employment contract. In cases of this type, the rights and obligations of the parties under the contract are suspended until the employee is successfully screened[8]. The failure of an applicant to pass a 'medical' in normal circumstances, typically results in the contract either coming to an end or not being consummated. Where no binding offer of employment is in place, no contract is made.

As a result, many recruitment policies are framed along the following lines.

Pre-employment Medical Examination

All applicants will be required to take a pre-employment medical examination to assess the prospective employee's fitness for work. All offers of work are conditional on an applicant satisfactorily undertaking the pre-employment medical examination and being assessed as fully fit for the work required.

To that end, a prospective employer is permitted to ask medical and psychological questions (including seeking information about an applicant's compensation history) only if those questions relate to the essential requirements of the particular job and the applicant's ability to do that job. It is unlawful to ask any other medical or related questions at this stage. If a question is asked that does not relate to the requirements of the position that the prospective employee has applied for, an unsuccessful applicant may then claim that the answer to that question was a ground for discrimination.

The converse situation also applies in the case where an employer uses extraneous information to assist in the making of an appointment decision.

O'Neill v Burton Cables Pty Ltd

In O'Neill v Burton Cables Pty Ltd[9], Burton Cables Pty Ltd was found to have refused to have employed O'Neill as a purchasing officer, on the basis that he had provided information to the examining medical officer that he had been suffering from back problems. As it transpired on presentation to the examining medical officer, O'Neill had indicated that he was stiff and sore as a result of digging in his garden. The examining medical officer had made the comments that O'Neill should have "been home in bed" and on that basis the company formed the view that O'Neill should not be employed as there was a risk that he would injure himself lifting goods. However it was held that there was little information on which such a judgment could be made. No attempt was made to obtain additional information from the doctor as to why these comments were included in the report and the previous employer had actually indicated to Burton Cables that O'Neill had no time away from work with back problems. In this case, the Victorian Equal Opportunity Board found that the company had treated O'Neill less favourably than it would have treated an applicant who did not have a stiff back. The company was found to be in breach of the equal opportunity legislation.

Pre-employment screening should take place only after it has been determined which applicants will be offered a job, with the offer of employment made conditional upon the successful completion of the medical examination. This is subject to the overriding qualification that any disqualifying conditions discovered as a result of the examination relate to the essential requirements of the job.

In ordinary circumstances, prospective employees should sign a consent form before any testing is undertaken. That form should also advise them, in detail, about the nature of the test that they are undertaking and explain the criteria for the successful completion of the test. The form should confirm that the testing is being undertaken by an independent medical expert and that the results of the tests will remain confidential.

Testing in the General Course of Employment

The **second category of case** that can be identified within the fitness for work continuum, places importance on the role of the employee at work. In the case of the existing employee, it is an essential requirement of the contract of employment that the worker be ready, willing and able to perform the inherent requirements of the position. State health and safety laws add to that common law obligation.

In the case of mining, the capacity of the worker is often assessed within the following impairment dichotomy:-

(1) **Cognitive impairment** (eg alcohol, personal fatigue or improper use of drugs); and
(2) **Physical impairment** (eg musculoskeletal injuries, sprains and strains, major injuries etc).

The question as to whether it is reasonable or not to expect that a worker must submit to ongoing health assessments so that an employer may interrogate for signs of cognitive and physical impairment was addressed recently in the case of *Blackadder v Ramsey Butchering Services Pty Ltd*[10]. In that case, Madgwick J stated that there should be implied by law into contracts of employment where necessary, that an employer be able to require an employee to furnish particulars and/or medical evidence affirming the employee's continuing fitness to undertake duties. In *Blackadder,* the requirement to submit to a health test, came about because of a shift in work requirement and the precautionary step the employer was taking to ensure that the employee was capable of undertaking the alternate duties, having regard to a previous injury that the employee had claimed to have suffered.

In *Blackadder*, the employee had agreed to the following:-
"if hired my continued employment may be contingent upon satisfactorily passing a physical examination at any time to establish my capability to properly or safely perform my duties."

Yet even in the absence of contract, the employer's justification for pursuing this right can be traced back to the decision in *Hamilton v Nuroof (WA) Pty Ltd*[11]. In that case, the High Court held that an employer has an obligation to take reasonable care for the safety of the employee in all the circumstances. These obligations are now well established under statute. An illustration of this is in the case of the safety and health obligations set out in Part 3 of the Mining and Quarrying Safety and Health Act 1999.

Against that back drop there seems to be little doubt that the right to test an employee in the general contract of employment, in certain circumstances, will be justified.

The major developing issue is not so much a union challenge to that right, but the dispute over the appropriate medical examination. Unions are challenging the employer's right to nominate their doctor of choice. They often claim that the employee has the right to nominate their own doctors and the employer is bound by that doctor's report.

There have been a significant number of dispute hearings over this issue in the past 12 months. Unfortunately there is no definitive case law yet. The closest we have to the Courts' view on disputed medical opinion, is the decision of the Full Bench of the Australian Industrial Relations Commission (AIRC) in *Lewis v Mobil Oil*[12].

Assessment as a Consequence of Accident or Injury

The **third discrete category of case**, focuses on processes that ordinarily flow from workplace specific accident or injury. There are several issues that emerge here.

Firstly, aside from the moral obligation that employers may have to take responsibility for workers suffering injury or illness as a result of their work, all workers compensation systems require employers to take responsibility to rehabilitate workers suffering from work related injury or illness. To this end, medical and treatment providers become involved in all aspects of assessment and treatment of an injured worker so as to:

- Establish diagnosis
- Determine current treatment regimes and requirements to maximise recovery
- Establish prognosis and timeframes for recovery and return to work if not at work
- Provide the doctor with information regarding the workers' current work status and progress; and
- Provide details regarding pre-injury duties, hours and job demands.

There are a myriad of potential outcomes that may result from this form of assessment, these include:

- Return to same employer/same job
- Return to same employer/modified job
- Return to same employer/different job
- Return to different employer/same job
- Return to different employer/modified job
- Return to different employer/different job
- Retirement on ill health[13].

Given this fact, it is perhaps unsurprising that the AIRC has required some checks and balances in the assessment process.

(a) Right for a Worker to obtain a Second Medical Opinion

One case that has highlighted the degree of procedural fairness that is expected from the parties by the AIRC is that of *Hobbs v Capricorn Coal Mining Management Pty Ltd (CapCoal)*[14]. The relevant facts are as follows.

Hobbs' Case

Hobbs had been employed by CapCoal as a mine deputy in its Southern Colliery in August 1996. On 20 November 1997 he injured his left knee, while undertaking an inspection *underground. He eventually underwent arthroscopic surgery on his knee and because of complications was then unable to continue rehabilitation. Hobbs was deemed unfit for work by the Nominated Medical Adviser (NMA) and his employment was terminated. Hobbs then applied and was granted reinstatement by the AIRC.*

However, Hobbs required a medical clearance before being allowed to return to work. After some dispute, an arrangement was reached between the parties that Hobbs would see the NMA and that the NMA's report would be forwarded on to another doctor for assessment. Hobbs did not attend the appointment with the second practitioner and based solely on the NMA's assessment, CapCoal attempted to find Hobbs a position which would be suitable, given that his activities, as a result of his injuries, was now restricted. Alternative duties were unable to be found and again, CapCoal terminated Hobb's employment.

Hobbs again applied and was reinstated by AIRC. The AIRC found that this dismissal of Hobbs was harsh, unjust and unreasonable as CapCoal did not comply with the arrangement that had been reached. The tribunal found that CapCoal had made their decision unilaterally based on one medical opinion contrary to the parties arrangements.

In order to return to work, Hobbs again was required to undergo the agreed medical assessments. The procedures this time were adhered to and again Hobbs was found to be restricted in the activities he performed. Again, no suitable duties were found for Hobbs and his employment was terminated. Again Hobbs applied for reinstatement but this time, it was found that the reinstatement was not harsh unjust or unreasonable. On appeal, the Full Bench of the AIRC found that having regard to the duty of care imposed on mine operators and the role of the NMA, the NMA relied on all relevant material and compliance of directions of the earlier agreement. The termination was genuine and thus, not harsh unjust or unreasonable.

This decision highlights several factors. Firstly that in the interests of natural justice and procedural fairness both parties need to clearly understand the nature of the process and the procedural steps that are to be followed along the way. Secondly and perhaps more fundamentally is the expectation that no decision will be made to terminate one's employment without having regard to all possible relevant information that may assist the NMA and subsequently the employer, coming to an ultimate conclusion as to the ongoing capacity of the worker to continue in their role. It is interesting to note, that following this decision, the relevant legislation was amended in order to enshrine within the law the right of a worker to seek the second opinion of a medical specialist or NMA, in such cases where an employer was considering terminating or redeploying an injured or impaired worker.

Random Health Testing

The **fourth and final category of case** that we deal with relates to random health testing.

The right of employers to institute random testing, can also be claimed to arise from an implied term of the employee's contract of employment. It has been argued that this implied term relates to the right of the employer to direct an employee to carry out all lawful and reasonable commands. Naturally, there is a limit as to the directions that an employer can give and certainly in the case of low risk industries, one would question in the absence of any other material issues, whether such a right would in fact exist.

In *BHP Iron Ore -v- CFMEU*[15], the Western Australian Industrial Relations Commission in Court Session acknowledged the right of a company to introduce a policy of random drug and alcohol testing into the workplace, where there was otherwise no contractual right to allow employers to test. Although the Commission emphasised in its decision that it had been concerned to only review the industrial principles in the context of the mining industry.

BHP Iron Ore Pty Ltd v Construction, Mining, Energy and Other

At issue was the desire of the company to introduce a drug and alcohol program for all of its employees at each of its workplaces. The most controversial aspect of the proposed policy was that it required that an employee as a condition of employment submitted to random testing of a sample of the employee's urine. The Union's objection to the proposal was that the drug testing element of the program constituted an unreasonable intrusion into the privacy of the employees and that the urine testing for drugs is not a reliable indicator of actual impairment or intoxication.

In addition the Union argued that there was little or no evidence of prevalence of drug use by employees within the workplace or immediately before commencing work.

However the company argued that it was necessary to enable it to satisfy its obligations under the Mines Safety and Health Regulation. The company also acknowledged the privacy concerns raised by the Union and indicated that there were strict security measures designed to avoid any publication of test result and any other information given as part of the program.

Having regard to the expert evidence put forward by the company, the Court in Session considered that the testing process under the scheme was not unreasonable.

Logically, in the case of the employer, the primary obligation is to fulfil its statutory obligations in the workplace. In its decision the Commission noted that there was little or no direct evidence as to the extent, if at all, that the consumption of drugs was a problem at the workplace. Although having said that in the three years prior to the decision:

- An employee was killed at work, when the haul truck she was driving overturned. She was found to have a significant level of cannabis in her blood at the time of death and cannabis and a smoking pipe were found in the cab of the vehicle at that time
- Employees were caught smoking cannabis in the workplace
- Cannabis was found hidden in company equipment at various worksites; and

there are a myriad of obvious legal issues that arise in the case of random testing procedures. With respect to drug and alcohol testing, the greatest concerns articulated at the time of this decision were the potential for breach of confidentiality and the fact that records generated by the employer were not privileged from production in civil or criminal proceedings.

Less obvious issues of concern are likely to be raised in the case of fatigue testing, although like all issues that flow from the employment relationship, if handled poorly can lead to significant unrest. This could easily be manifested where screening processes caused supervisory intervention in an arbitrary fashion, with resultant claims of discrimination being levelled at those involved. Given the complex set of work and non-work factors that impact on employee fatigue, developments in this area should be watched with interest.

Is Mining Unique?

Health Assessments in Mining

So is the framework of 'Fitness for work' testing so different in the case of mining?

Undoubtedly, mining is a unique industry. This is evident by the types of hazards that have caused specific health and safety regulations to be created. And there is good reason for this. In Queensland, there have been approximately 140 fatalities in the metalliferous mining industry[16] and approximately 320 fatalities in the coal mining industry over the past 140 years[17].

Legge has identified 5 key attributes of work related assessments[20].

Table 1 - Key attributes of work related assessments

Safety	Is the test safe to administer
Reliability	Are the test results reproducible on any occasion between evaluators and participants
Validity	Does the test measure what it reports to measure and is it predictive of performance
Practicality	Is the test easy to administer with reasonable/minimal cost
Utility	Does the function al test relate to job performance and does it meet the needs of the involved parties.

Let us look at some of these attributes in the context of some of the fitness for work methodologies presently employed within the industry.

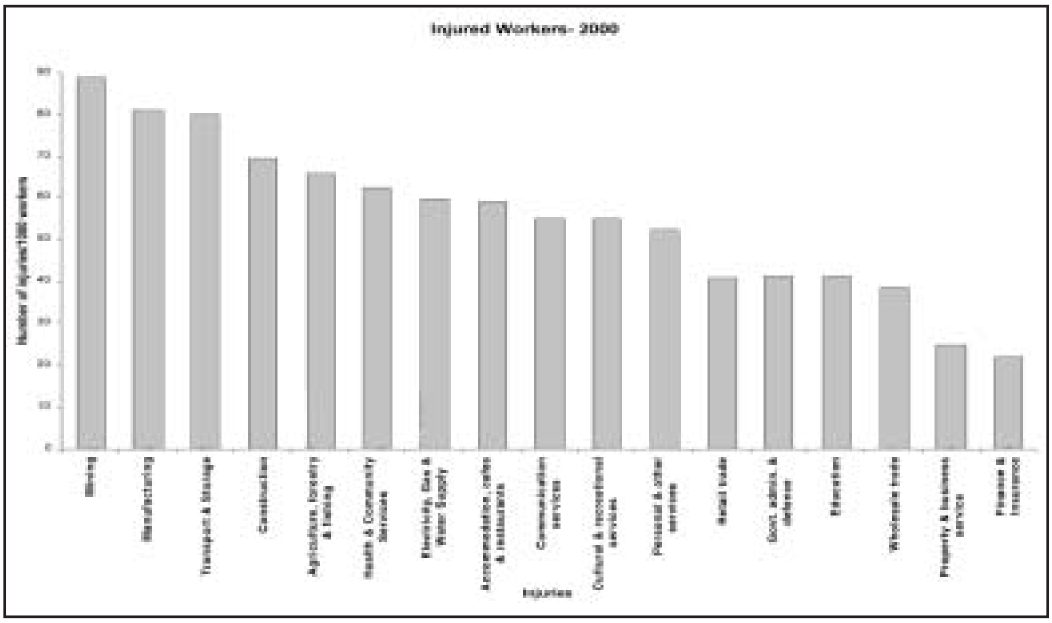

Figure 2
Source: ABS 2000 Work Related Injuries Survey.

As Figure 2 illustrates, in the Year 2000, mining recorded the highest number of workplace accidents in Australia. It is perhaps for this reason that the mining industry conducts more testing of fitness for duty than any other industry[18]. And it is largely as a consequence of the uniqueness of the industry and its hazards, that a separate regulatory scheme has evolved. The distinction between general industry occupational health and safety regulation and mining safety regulation, is very much borne from a recognition that on occasions the industry is viewed as having catastrophic and unique hazards and greater risks than that of general industry[19]. For these reasons, the role of the assessment process in mining, is viewed as a critical one.

Critical aspects of the Fitness Screening Process

One of the most critical aspects to the fitness screening process is ensuring that the medical examiner or health assessor well understands the context and actual job requirements that may be required of the individual. For example, in the case of a worker submitting to a medical examination in accordance with Section 87 of the Mining and Quarrying Safety and Health Regulation 2001, the adequacy of the background data supplied (such as functional demands of the job) provides the context in which the medical assessment is made. The validity of this information setting the context of the job, is viewed as critical and weaknesses in the quality of the information supplied, can be quite prejudicial to the accuracy of the assessment and the individual.

Testing Methodologies in Mining

In the case of coal mining in Queensland, the majority of fitness for work testing is conducted by way of health assessments undertaken in accordance with Section 46 of the Coal Mining Safety and Health Regulation 2001 (Qld). The scope of the assessment is prescribed by way of an approved form that serves to standardise the assessment regime through a panel of nominated medical advisers. This process seeks to achieve consistency in approach and recognition of the need to involve industry specific medical specialists working in this area.

By way of computerised test instruments, this conference has previously heard of the experience of Callide B utilising the FIT 2000 system, that enables quick automatic testing of significant impairment at work[21]. Another approach that we have already briefly mentioned is that of the functional capacity evaluations. Functional Capacity Evaluations (FCE's) can be relied on to predict the nature and extent of 'match' between on the one hand, a particular individual's capacities and limitations and on the other hand, the capacities demanded by a job or other activity[22]. In the case of the FCE's, there appears to be much discussion continuing on issues of reliability and validity of the assessments undertaken[23]. It may be for this reason that newer methods of testing are beginning to be reported. One example of this is in the case of Cadia Valley in New South Wales, who have considered the feasibility of equipment simulators (eg haul trucks and loaders) in order to develop more appropriate performance indicators for assessing the impact of fatigue or stress[24].

Contentious Issues

Against the above backdrop lies a potential battleground for litigation. So why does something which on its face seems so logical and worthwhile, become such a contentious issue? At the level of the individual, there are very real issues at law in terms of rights of the employee insofar as they pertain to discrimination, privacy, confidentiality, the inherent requirements of a position and the capacity of the employer to make reasonable adjustments where disability or impairment is not in itself a barrier to performance. For the employee, existing fitness for work testing procedures can be the stimulus for claims of intimidation and unfair treatment.

In addition, there is anecdotal evidence that issues do become industrial, whether legitimate or not. Some of the apparent hostility manifests itself on the basis of a difference in views as to what are the legal entitlements of the parties having regard to the employment relationship. For example, one circular sent out within a mining district stated that the relevant Union had been advised by a statutory appointee that companies had a common law right to send any mineworker to a nominated medical adviser. It went on further to indicate that this advice is totally inconsistent with the Union's interpretation of the intent of the relevant Mining Act and will be rigorously opposed by the Union. In that context, where consent to a process is not forthcoming, issues of medical assault and claims of acts against your will, also emerge.

The situation can be compounded further where disputation over which medical adviser is appropriate, also takes place. We see a worrying trend where the unions allege one doctor is pro-employer and the employers allege one doctor is pro-employee. This seems to go beyond the usual and understandable debate that different doctors genuinely can interpret the same results with different outcomes.

Issues of Discrimination & Unfair Dismissal

General Principles of Anti-discrimination Law

Anti-discrimination law impacts on all four categories of a case. At both the state and federal level, there is legislation prohibiting discrimination in an employment situation. For example the Disability Discrimination Act 1992 (Cth) prohibits discrimination on the basis of a disability which is defined at Section 4 of the Act to include:

(a) Total or partial loss of a person's bodily or mental functions; or...
(c) The presence in the body of organisms capable of causing disease or illness; or...
(g) A disorder, illness or disease that affects a person's thought processes, perception of reality, emotions or judgement or that results in disturbed behaviour.

Section 15 of that Act provides that it is unlawful for an employer to discriminate in determining who should be offered employment, deny an employee access to promotion transfer and training, dismiss an employee, or subject the employee to any other detriment because of discrimination on the ground of a person's disability.

At the State level, the Anti Discrimination Act 1991 (Qld) prohibits discrimination on the basis of physical impairment. 'Impairment' is defined in that Act in similar terms to the definition of 'disability' in the Disability Discrimination Act 1992 (Cth).

When Discrimination is Permitted

Discrimination is permitted in certain circumstances. Under the Federal Act, discrimination is permitted where:

(a) The disability prevents a person from carrying out the inherent requirements of the particular employment; or
(b) In order to carry out those requirements, facilities would need to be provided which would impose an unjustifiable hardship on the employer (section15(4)).

In the case of the Queensland Act, discrimination is lawful where:

(a) The circumstances of the impairment are such that they would impose unjustifiable hardship on the employer (section 36); or
(b) The discriminating act is done to protect the health and safety of people at work(section 108); or
(c) If the discriminating act is done because of a genuine occupational requirement for a position (section 25).

Additionally, some anti-discrimination legislation, for example section 106 of the Anti-Discrimination Act 1991 (Qld) exempts discrimination in circumstances where it is necessary to comply with other relevant state or federal laws.

Earlier on in the context of pre-employment screening, the issue of discrimination was briefly canvassed. The objectives of the anti-discrimination and industrial relations laws appear largely the same. By far the majority of complaints in this area are likely to arise where a worker is deemed to be no longer physically capable of performing his or her duties. In cases of this type, termination is invariably a consequence of the incapacity of a worker to physically continue within the role or the workplace. The importance of determining objectively what are the occupational requirements of a position and whether or not there can be some modification of duties (for example) so as to accommodate the impaired worker within the workplace, therefore become critical, as tribunals are asked to assess whether a worker has been treated fairly as a consequence of fitness for duty testing.

Termination of Employment

In the case of statutory protections given to workers under termination law, the general considerations for the parties are largely the same. There are several ways by which a contract of employment can come to an end. These include by:

- Mutual agreement
- Serious breach of an essential term
- Inability of one party to perform their duties within the contract; or
- By way of a supervening or frustrating event.

But against these basic common law rights, statutory provisions have been created and for the past decade now, the potential remedies that are available to employees under statute, have become quite important in the way to proceed with the outcomes of a fitness for work testing procedure.

(a) Remedies Available in the Federal Jurisdiction

At the Federal level, section 170CE(1) of the Workplace Relations Act 1996 (Cth) sets out the grounds by which an employee whose employment has been terminated by an employer may apply for the relief of the Australian Industrial Relations Commission. (AIRC) These include:

- On the ground that the termination was harsh, unjust or unreasonable [Section 170CE(1)(a)]
- Temporary absence from work because of illness or injury within the meaning of the Regulation 30C [Section 170CK(2)(a)] and
- Physical and mental disability [Section 170CK(2)(f)].

The case of *Ian Hobbs v Capricorn Coal Management*, has already been raised where the unilateral decision to terminate an employee on the grounds of incapacity, was seen as a violation of an approved process the result of which amounted to an action that was harsh, unjust or unreasonable. What is becoming abundantly clear is that new battlelines are being drawn and battles fought in cases where there is a lack of consistency in opinion among medical practitioners. At issue are competing views as to the longer term prognosis of the worker and often allegations of premature decisions taken by employers to terminate workers in cases where ongoing rehabilitation or alternate duties should have or could have been provided.

The second potential ground available for the employee, is to make an application on the basis of the physical disability arising from the injury, in contravention of Section 170CK(2)(f) of the Act. In cases of this type, the application can be pursued through either the Federal Court or the Australian Industrial Relations Commission. Again reinstatement in these cases may be harder to secure than initially thought. One of the traditional tests that the AIRC must consider is the 'practicability' of the reinstatement having regard to all of the stakeholders.

The tension between the disability of the worker and the right of the employer to secure and maintain a safe workplace environment can be illustrated in the decision of Marshall J in Patterson v Newcrest Mining Ltd[25], where he stated:

I am most reluctant to order the reinstatement of a employee to her or his former position if so doing involved a real and substantial risk of the employee being seriously injured upon her or his return to the position occupied prior to the termination of employment.

It is for this reason that workers pleading termination on the combined grounds of harsh, unjust and unreasonable as well as based on discrimination, must now elect whether they pursue their claim in the Australian Industrial Relations Commission or the Federal Court, on the basis that the difference in remedies available, appears to be in part in recognition of the complexities associated with disability claims.

(b) Remedies Available at the State Level

With some minor exceptions, the provisions of the *Industrial Relations Act 1999* (Qld) are set out in fairly similar terms to that of the Federal legislation. However there are two relevant provisions within Part 5, Chapter 3 of the Act that deserve comment. Section 93 of the Act provides that it is unlawful to terminate an employee who becomes injured within the first 6 months of that injury and under Section 95(2) an injured employee who was terminated because of that injury, may apply to the employer within 12 months after the injury for reinstatement to his or her former position. For the later situation to occur, the employee must give the employer a doctor's certificate that certifies the employee's fitness to return to work and in the event that the employee is not immediately reinstated by the employer, the employee may apply to the Queensland Industrial Relations Commission for reinstatement. One wonders the implications of these provisions where competing views of medical practitioners prevail and where for example, an NMA under the Coal Mining laws has declared a person permanently unfit to work in mining.

Roles & Rights of Parties in a Fitness for Work Environment

Recent Experiences within the Coal Industry
(a) Role of Industry Safety & Health Representatives

Given the various legal issues that impact on the parties, it is natural enough that the development of fitness for work policies at workplaces often creates significant industrial unrest. This was recently observed in relation to the revision of the fatigue management policy at Oaky Creek Mine[26]. At issue was the role of the industry safety and health representative and whether an automatic right existed for the representative to be become involved in the consultation processes imposed on a site senior executive. Section 10 of the *Coal Mining Safety and Health Regulation 1991*, sets outs the steps that must be taken in developing standard operating procedures for managing and controlling hazards at a mine. Section 42(6) of the Regulation sets out the consultation requirements imposed on a site senior executive when developing fitness provisions, such as a fatigue management policy. These requirements include consulting with a cross section of workers involved in carrying out a task under the proposed procedure and providing those workers with a copy of the draft standard operating procedure, or in this case the proposed draft policy.

The Oaky Creek Case

In this case, it was the submission of the employer, that Sections 10 and 42 of the Regulation had no bearing on the issue in dispute. The company argued that those sections only relate to the creation of new health and safety procedures and have no bearing on the requirements of the parties where they wish to revise existing procedures. This argument was rejected by the court. The court held "nothing in Reg 42 suggests that to "develop" a procedure, means only to "create" one out of nothing. Fryberg J makes clear that the capacity of a representative to participate in a review of the fatigue management policy is likely to reside in at least one of the paragraphs within Section 118(1) of the Act, where the functions of the representative are set out. However his Honour, concluded that the mere fact that participation would have been within the ambit of the functions of a representative, does not mean that the representative had an automatic right to participate in the process. Within the judgment his Honour illustrates this by giving an example of circumstances where a representative may not be invited to attend, or where the workers specifically seek to exclude the representatives from the process.

This issue is likely to be one where much more industrial negotiation shall take place.

(b) Role of Negotiating Agents in the Coal Industry

The second issue that remains largely unexplored is whether an industry representative (or a lawyer for that matter) can assume the role of agent for workers where such agency is sought to be established. His Honour declined to express a view in relation to this issue, although on the basis that there is no expressed function of agency set out within Section 118 of the Coal Mine Safety and Health Act 1999, it would seem fairly unlikely that such a role would be consistent with the statutory one for a representative that is already quite clearly defined. This issue is also most likely to surface again.

Rights of Lawyers to Monitor Health Assessments

Finally and on a lighter note, one wonders how much more sophisticated or legalistic, the concept of fitness for work will become. In the United States, for example, there exists the right for a defendant in a personal injuries proceeding to have a medical examination videotaped and to allow counsel to monitor the examination from an adjoining room. In *Freeman v Latherow & Ors*, it was the defendants who sought to preclude the plaintiff from undertaking this taping, presumably in an attempt to spoil the validity of the medical assessment[27].

Hopefully, this will not be illustrative of the future Australian way.

General Rights of the Worker

Finally, we briefly consider the rights of the worker. It is well established that persons do not by virtue of their status as employees lose their right to privacy and integrity of the person. An employer could not at common law assert any inherent right to subject an employee to a physical examination without consent. Indeed, an employer or a doctor who forces a medical examination on a person may be liable to assault or battery. Section 245 Criminal Code 1889 (Qld) defines assault in wide terms to include striking, touching, applying force or threatening to apply force without that person's consent. For example, the taking of blood against a person's will and in the absence of any statutory duty, will likely constitute assault under the Criminal Code.

However, while the employer cannot force an examination in that sense, an employees refusal to comply with a lawful and reasonable request can still be grounds for termination of the employment. That is, the laws will not protect an unreasonable refusal to have a medical examination.

One final issue that is important to consider is the way in which the employer undertakes personal information management. It is imperative that an employer has an appropriate understanding of the privacy issues involved from the initial occasion that employee information is collected through to processes for information disposal[28]. Employee medical records will need to be kept confidentially to ensure that the employer does not breach any fundamental principles. Employers should also be mindful of the 'need to know' principle that logically discourages medical information to be circulated freely within HR departments during injury management processes.

Conclusions

Undoubtedly, fitness for work is an important issue confronting both employers and past, present and future employees. This is especially so in the mining industry where the risks are higher, and the legislation tougher. Complex issues abound in all categories of case. Consequently, employers and employees should be aware of the rights, roles and responsibilities that each hold when approaching the subject.

Advances in technology, medical specialisation and the greater capacity of individuals to articulate their rights, will all be phenomena that assist in helping improve the policies and processes for ascertaining one's fitness for work. Like most workplace issues, addressed fairly and objectively, appropriate outcomes are achievable. What remains clear though is that "fitness for work" is a very complex issue. Given that medical examinations have been undertaken since ancient Egyptian times, there must be much that can be learnt from what has gone on to date. Clearly all stakeholders need to be put on notice that the processes are quite complex and that no easy answers lie in the administration and aftermath of the testing procedure.

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Behaviour-based Safety: A Case Study Illustrating a Successful Approach

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Abstract

Industry is becoming increasingly aware of the importance of taking human factors into account in safety management, particularly in the mining industry where human operations dominate. Accidents are commonly attributed to at-risk behaviour or human error. When accidents are investigated, many of the systemic causal factors are human in their origins, eg: inadequate training, bad design or poor safety culture.

Behaviour-based safety programs have become a popular approach to managing the people issues in safety. However in many ways, programs have not delivered on promises and organisations have been left dissatisfied. Common complaints of traditional approaches to behaviour-based safety are (a) narrow scope, focused on behaviour change rather than concurrently addressing causes for at-risk behaviour, (b) one-size-fits-all approach rather than a BBS system tailored to organisational characteristics and culture, (c) poorly integrated with existing safety management systems.

We recognise the weaknesses of many of the traditional approaches and have developed an alternative approach that is proving to be successful. We will discuss our approach using a case study of our recent success with a large manufacturing client. We will illustrate the framework we used and the reasons behind its success. We will discuss application of this approach in the mining industry.

Industry is becoming increasingly aware of the importance of taking human factors into account in safety management. This is particularly the case in the mining industry where human operations dominate. In the past, safety has been managed primarily as a technical problem, that can be "engineered out". More recently, it is becoming widely accepted that technical approaches alone are inadequate to reduce the accident rates to desired levels (Reason, 1997). In other words, even when the purely technical problems are addressed, unacceptable accident or injury rates often persist.

What is Behaviour-based Safety?

Behaviour-based safety approaches have become a popular way of managing the people side of safety. The approach was originally developed in the USA. It revolves around what motivates and reinforces people's behaviour. Basically it was recognised that the rewards for behaving unsafely often outweigh the rewards for safe behaviour. For example, common rewards that increase the likelihood of behaving *unsafely* include:

"The boss congratulated me for getting the job done faster"

"I met my production target in a shorter amount of time, so I could take a longer break"

"It's easier to do it this way and I didn't get hurt".

When people experience these sorts of rewards for unsafe behaviour, they will be more likely to behave that way the next time around. This is why short-cuts can often become the norm, with phrases like "That's just the way things are done around here" being commonplace.

Behaviour-based safety programs attempt to address the balance of rewards for behaviour by increasing rewards for *safe* behaviour and decreasing rewards for *at-risk* behaviour. Traditional behaviour-based safety programs attempt to achieve this objective by:

- Educating people in the workplace about safe and unsafe behaviour
- Using peers and supervisors to observe worker activities
- Isolating target behaviours
- Providing various forms of feedback to individuals and groups in order to positively change safety-related attitudes and behaviours.

This feedback usually comes in the form of praise and recognition from peers and/or supervisors.

Traditional approaches to Behaviour-Based Safety state that…

- Almost all incidents occur from *unsafe acts*
- For every accident, there are many *unsafe behaviours*
- Identify key *unsafe behaviours*
- Train workers/management to observe workers
- Perform observations
- Provide feedback to reward safe behaviour and draw attention to *unsafe acts*.
- Record and use data from observations *(Adapted from USWA)*.

The fundamental concern about traditional behaviour-based safety programs is that to some extent, they assume that we always have a choice as to whether to behave safely or unsafely. For example, there is an underlying assumption that if haul truck drivers speed or drive recklessly, it is because they choose to do so. Behaviour-based safety programs suggest that if an individual was rewarded for safe behaviour then safer driving would occur.

However, speeding or erratic driving can also be a result of a number of other factors that are not necessarily under a person's control, such as fatigue, poor vehicle design or a culture of production before safety. Therefore, behaviour-based safety programs should not simply focus on individual behaviour change. They need to simultaneously address individual behaviour, systemic factors that contribute to unsafe acts and organisational culture. While this conceptual transition is beginning to occur (Manuele, 2000), many industries are still struggling with putting these new approaches into practice. We illustrate our approach to behaviour-based safety that attempts to overcome this and other problems associated with traditional approaches to behaviour-based safety.

Case Study

A large paper manufacturing company in Australia recognised that many of the injuries and incidents that were occurring at two of their paper mills were attributable to at-risk behaviour. Therefore, the introduction of a behaviour-based safety program was seen to be an appropriate approach to address this issue. However, the initial pilot test of an "off-the-shelf" behaviour-based safety program was largely unsuccessful. This was attributed to several factors, which can be summarised as:

- Failure to establish workforce buy-in and commitment to the process
- Workers and unions were concerned about the principles behind behaviour-based safety. That is because they saw it as an attempt to change worker behaviour. The program was seen as a way of management to "pass the buck" for safety to the workforce and it was seen as a way of attributing blame for incidents to individual workers
- The program was too advanced for the current organisation and its workforce to cope with
- The program was not well integrated with existing systems and the required infrastructure was not in place to support the program functioning.

These issues were taken into account and a revised strategy was formulated for the way forward. It involved four phases:

• Phase 1: Assessment

A "rich picture" of the current workplace and workforce characteristics was developed. This picture was developed via (a) an assessment of the current safety culture and (b) a review of current safety management systems. Safety management systems were reviewed through interviews with key site personnel, using a series of structured questions about the safety systems and procedures currently in use.

Safety culture can be essentially characterised as "the way things are done around here with respect to safety". Safety culture measures are a "snapshot" giving insight into the way people are thinking and feeling with respect to safety. Safety culture was assessed by interviewing and surveying a representative cross-section of the workforce about their perceptions and attitudes towards safety. A good understanding of the current culture was developed, giving management an important insight into the way that the workforce "thinks" with respect to safety. Some of the factors that were assessed included:

- Attitudes towards taking a pro-active involvement in safety
- Perceptions of management commitment to improving safety in the workplace, and
- Attitudes towards short-cuts
- Degree of complacency.

The major strengths and risk areas from a culture perspective were identified.

The major incident causes were also determined by reviewing a set of recent incidents. This was important in defining the key hazard areas and the sorts of tasks and behaviours that were most critical to address.

• Phase 2: Design

The workforce were actively involved in the development of the new behaviour-based safety program. This involved workshopping the design of the program with key representatives from management, shop-floor and unions. The resulting program was much simpler than the original program. It was recognised that starting with a simple program helps develop workforce acceptance, because it is more accessible and easy to grasp. Ideally, once the program is successfully implemented at a simple level, the workforce can then suggest improvements and developments over time, which improves workforce ownership of the program.

The resulting program essentially consisted of a combination of general hazard observation programs and behaviour-based safety programs. The key elements were that the program gives everyone an easy way of reporting a hazard if they see one. Hazards could be behavioural in nature or they might be factors that might lead to unsafe behaviour/human error. Everyone one-site was trained to identify hazards and identify factors that can contribute to human error and also to think creatively about potential solutions. The trends from the hazard observation forms were also central to being able to detect underlying systemic issues and developing solutions.

• Phase 3: Implementation

The program was phased in over three months across two paper mill sites. Every person working on-site (approximately 700) was trained. Importantly, training groups were small (approximately 10 per group) to facilitate interaction and the training groups represented a cross-section of people across the site. Representatives from management and shop-floor were integrated, which assisted in breaking down some long standing hierarchical barriers. Sessions were interactive. The behaviour-based safety program was actively "practiced" in the training room and potential obstacles to success were identified and resolved during these training sessions.

Participants were not only taught *how* to participate in the program, they were also encouraged to actively brainstorm *why* a program such as this would be helpful in addressing safety at their worksite. Participants became noticeably more enthusiastic and involved when they had generated their own reasons why the program would be of value.

Participants were taught how to identify unsafe acts as well as to identify factors that might be contributing to unsafe acts, such as hazardous conditions or procedures.

The training sessions were also used as a vehicle for culture change. That is, aspects of the culture that had been detected as issues in the initial culture assessment to do with morale and workplace satisfaction were addressed and one example of how this was addressed was via interactive team-building exercises incorporated into the training sessions.

• Phase 4: Follow-up

A commonly reported reason for program failure is inadequate follow-up once the program has been implemented. Informal strategies for follow-up included attendance at safety meetings and "walking the floor" in order to identify any obstacles to success. As would be expected with the implementation of a new program, there were a number of issues that threatened the success of the program. Many of these were detected by those on shop-floor once they began to participate in the program and those representatives who identified the problems were encouraged to be involved in the development of appropriate solutions. This assisted in building morale and promoting a smooth implementation of the program.

To date, just under 6 months since program implementation, over 400 hazard observation forms have been lodged. The hazards observed have been addressed via specific solutions (e.g. re-design of equipment) or by general solutions that help to address a range of similar hazards, (e.g. training programs for detecting and recovering from human error). There has been a reduction in medical treatment injuries since implementation of the program.

A formal follow-up assessment will take place approximately 6-12 months after program implementation. This will involve re-measuring safety culture and safety performance and comparing this to the original assessment in order to determine program success. This is important in estimating return on investment, but also very important in developing continuous improvement strategies to avoid the program becoming stagnant.

Factors Behind Program Success

The implementation of a successful behaviour-based safety program is reliant of a number of factors. Here we outline the principles that we believe are crucial to program success. We use examples from the case study above to demonstrate practical strategies for achieving these objectives. Where relevant, we also demonstrate how these principles improve on many of the traditional approaches to behaviour-based safety and why the approach that we took in the manufacturing industry might also be a beneficial approach to managing the people-related safety issues in the mining industry.

1. Establish Workforce Acceptance & Commitment to the Program

A behaviour-based safety program is all about effecting change in an organisation. Managing the change process is a critical success factor for any new program introduced into the workplace.

The challenge of the change process can be met in several ways. Essentially what is sought is workforce acceptance and commitment to the process. A central aim is to get workers to buy-in to the program and see the benefits for themselves. This can be achieved in a number of ways. Firstly, involving workforce representatives in the design of the program enables them to feel as though they have control in the outcome and enables them to have a sense of ownership of the program. These representatives form a steering committee. These representatives become active advocates of the program, so selection of representatives who have credibility and influence at shop-floor level is important.

Another good strategy for getting workers to buy-in to the program is to get them to generate their own ideas as to the benefits that can be realised with the introduction of a behaviour-based safety program. This can be done as part of the behaviour-based safety program training sessions. Asking the workforce to generate the advantages of the program increases the likelihood that they truly *believe* in the value of it, rather than simply being told.

Once the program has been implemented, commitment can be enhanced by the careful provision of prizes or rewards. There is much dispute over the pro's and con's of rewards given for safety. The downside is that rewards may trivialise safety and represent safety as a "game" rather than as a core value. However, with behaviour-based safety programs, rewards may be useful in acknowledging the identification of a very serious hazard or acknowledging an excellent recommendation for a way to eliminate a hazard (Frederick & Lessin, 2000). It rewards critical thinking and thoughtful involvement.

Finally, emphasis should be placed on the proactive nature of the program. It is important to show the workforce that this program enlists the expertise of every person in the workplace in detecting and correcting the causes of injury *before* they occur.

2. Ensure that the Program is Applicable to your Organisation & its Unique Characteristics

Industries and organisations vary considerably in the type of work that is conducted, the way it is carried out, the organisational structure and the culture of the workforce. There are also specific workforce factors, such as level of literacy and cultural background that also need to be carefully considered in the design or selection of a suitable behaviour-based safety program.

Three factors are critical to ensure the applicability of the program to your organisation. Firstly, the need for pre-assessment of the characteristics and culture of your organisation should not be underestimated. This will guide your selection of the type of behaviour-based safety program and development of specific goals and objectives that you want to achieve with the program.

Secondly, engaging the workforce in actively designing the program is important in ensuring that the workforce will accept and use the program. A taskforce or committee made up of a cross-section of representative employees is recommended. Actively involve your workforce in the design of the specific characteristics of the program, e.g. what is going to be observed, who is going to observe, how is the information going to be fed back to the workers, can we integrate the process with other systems and processes in place, and so on.

Thirdly, every organisation has certain tasks when safety is habitually violated. For example, working on certain machinery without turning it off, walking across a conveyor that is active. These habits occur because taking a particular risk saves time or energy but causes no personal injury. Workers will repeat this behaviour over and over until eventually this behaviour becomes habit – behaviour that is chosen so quickly that it is an unconscious decision. The danger emerges when a set of circumstances arise that makes this behaviour more risky than usual (eg. Equipment jams or protective devices fail). The barriers that usually prevent common behaviours from causing injury are no longer present. This is when an injury occurs which usually takes everyone by surprise. Accidents are not random but arise from the nature and function of the organisation.

Therefore, the unique characteristics of the organisation need to be taken into account to determine what the behavioural factors are in this particular organisation that need to be considered. Those subtle, convenient and seemingly safe behaviours need to be identified as they form a fundamental part of ensuring that your behaviour-based safety program is relevant to your workplace.

3. A Holistic Approach to Addressing At-risk Behaviour

Traditional behaviour-based safety approaches attempt to change worker behaviour. Targeting specific behaviour is a good start. As discussed, traditional approaches to behaviour-based safety focus their efforts here by rewarding safe behaviour. While this can have some success, it not the complete picture.

It appears that many workplaces using these programs are much more likely *not* to address the hazards and systemic factors that are often the root cause of unsafe acts (Ref). Human factors thinking has moved on from the old idea that our systems would be safe *"were it not for the erratic behaviour of some unreliable people (bad apples) in it"* (Dekker, 2002).

The behaviour-based safety program must simultaneously address the specific behaviours and systemic factors that contribute to at-risk behaviour. In some ways, traditional behaviour-based safety programs have placed too much emphasis on behaviour-change. This has been criticised as "turning the hierarchy of controls upside down, contradicting one of the most widely accepted concepts in injury and illness prevention" (Howe, 1998, p.6). Most approaches to behaviour-based safety include references to studies from the DuPont Company which indicate that the "causes" of most industrial accidents (up to 96% in some studies) are the "unsafe acts" of workers. According to these studies, very few industrial accidents are caused by "unsafe conditions". Our approach recognises the need to address safety from both perspectives: the unsafe act and the precursors that contribute to this unsafe act.

As James Reason suggests *"free will is an illusion because of range of actions is always limited by the local circumstances"* (1997). Workers need to be trained in understanding the factors that contribute to human error. Following the widely accepted Reason Model of Error (Reason, 1997), there needs to be a distinction between wilful at-risk behaviour versus behaviour that stems from underlying systemic issues such as:

- Organisational culture, eg. a culture of complacency, production before safety
- Management decisions
- Fatigue due to shift structures
- Poor workplace design
- Inadequate tools and equipment
- Time Pressure
- Inadequate Training.

Training needs to focus on hazard perception as well as behaviour-observation techniques.

The data from observations should be capitalised on. It provides an excellent way of being able to identify patterns or systemic issues contributing to at-risk behaviour in the workplace. Good use of this data can guide where safety efforts and resources are targeted.

4. Ensure Appropriate Infrastructure to Support the Program

If the system that is developed fails to fit users' work practices, then it will be underused and unlikely to facilitate cultural change (Tavistock Institute, UK).

The Tavistock Institute in England developed the Sociotechnical Systems approach to managing change (Trist, 1981). It was first developed in the 1930's in the mining industry in the UK. It acknowledges that people are a core part of organisations and looks at ensuring that structures and processes in the workplace are aligned or matched with people, in order to maximise efficiency and job satisfaction. This is a central principle for managing the smooth integration of a behaviour-based safety program into the workplace. Careful thought needs to be directed towards ensuring that there are appropriate structures and processes in place to support rather than impede the behaviour-based safety program. For example:

- Avenues for communication and feedback
- Data collection and management processes, i.e. a centralised database
- Clear definition of roles and responsibilities.

There needs to be user-friendly procedures for observation, lodging forms, giving feedback, following up on identified hazards, and so on. The integration of the people with the system should be seamless.

Another point to make is that management are key players in the process (Cook & McSween, 2000). Managers across all levels must receive targeted training in their specific role in the behaviour-based safety program. At the middle management level, their role in the behaviour-based safety process centres around:

• Detecting glitches in the system and resolving these
• Maintaining workforce motivation and commitment to the process
• Leading by example and actively "walking the talk".

Specific training is required for this level of the organisation acknowledging that they are the lynchpin in the process.

5. Establish Long-term Sustained Success

The ultimate aim of any behaviour-based safety program is to develop and sustain a positive safety culture. Many programs appear promising to begin with, but once the initial momentum slows down, they do not result in sustained change.

It is important to assess safety culture to begin with and develop goals and objectives for the desired culture. The gaps between current and desired culture guide the design of the behaviour-based safety program as a way of actively addressing these weaknesses. It is equally important to conduct follow-up assessments to determine what aspects of safety performance and safety culture have improved and where areas for further improvement are evident.

In order to achieve sustained culture change, one of the key proponents of behaviour-based safety programs has acknowledged that it is important to start "small" and allow employees time to get used to an observation and feedback process before adding too much complexity (DePasquale & Geller, 1999). We achieved this by developing hazard cluster categories (e.g. People, Process and Plant related) rather than identifying specific target behaviours. In the next phase, critical behaviours within these clusters can be defined and this is best driven by the workforce.

It is important that the program is aligned with current systems and processes and ways of doing things. If the program is too far removed from other management systems, it increases the likelihood that the program will not be sustained over a long period of time. A good way of maintaining continuous improvement and avoiding the program becoming "flavour of last month", is to write key performance indicators associated with the program into management performance appraisals.

Finally, the bottom line is that behaviour-based safety programs need to demonstrate return on investment. We need to be able to measure and track safety performance improvements. Difficulties with measuring safety are beginning to be overcome, by using a combination of measures that not only track poor safety performance (eg. LTI rates) but also track system health (e.g. Safety Culture) (Dumsa, et al, in press). The initial pre-assessment of safety is vital in being able to demonstrate improvements from baseline performance as a result of the behaviour-based safety intervention.

Interestingly, an example of the link between good safety performance and good organisational performance is evidenced by Paul O'Neill, the former CEO of Alcoa in the U.S. His overall leadership strategy was to make safety improvements. His principle was that when organisations function at a high level in safety, many positive things follow, including improvements in morale, communication and a sense of cohesiveness within the organisation. These factors are commonly attributed to high performing organisations (Peters & Waterman, 1982; Senge, 1990). Some findings from research reveal that there are many important side benefits of behaviour-based safety that improve general organisational functioning. Some of these include: improved employee awareness, culture, communications, involvement, quality and productivity (Krause, 2002).

Conclusions

This paper has illustrated an approach to behaviour-based safety that was undertaken in the manufacturing industry. The approach has overcome many of the problems associated with more traditional approaches to behaviour-based safety. We believe that this approach holds a lot of promise for the mining industry. Mine sites face similar problems to manufacturing sites with respect to managing people issues in safety. There appears to be a requirement for a program that better integrates behaviour observation and change with strategies for managing human error and it's causal factors. There also appears to be a need for a program that is both accessible and acceptable across the entire workforce.

The case study outlined in this paper demonstrates that our approach to behaviour-based safety undertaken in a large Australian manufacturing organisation, in the first 6 months of implementation, has already begun to show significant improvements in safety performance.

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Developing a Crisis Management Capability - Curragh Queensland Mining Pty Ltd Meets the Challenge

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Steve Ward, Curragh Queensland Mining Pty Ltd

In November 2002 a full scale mock crisis was played out at the Curragh Queensland Mining Pty Ltd mine near Blackwater. The exercise involved not only mine personnel but representatives from all major stakeholder groups and Wesfarmers Energy. Taken in isolation, this activity would undoubtedly draw some recognition for the efforts of the organisation in undertaking this type of activity. What wouldn't have been known is that it wasn't just an exercise but rather the culmination of a number of years commitment to emergency and crisis preparedness by Curragh. This paper looks at the background and lead up to the exercise and tracks the development of a 'real' crisis and emergency capability.

Introduction

In an industry high in inherent risk there has, quite rightly, been a focus on risk and emergency response. Legislation directs it and companies commit resources to it. However in recent times there has been some recognition that just having the ability to deal with an incident from an emergency response perspective is not sufficient and in fact fails to address a key aspect of dealing with a major incident, that being management's response.

In 1998 Curragh undertook to develop a comprehensive capability in the area of emergency and crisis management. In broad terms, the situation at Curragh at that time is demonstrated by the following diagram which shows the relationship between risk assessment, risk mitigation and emergency response.

Risk Assessment	Risk Mitigation	Emergency Response
Identification and analysis	Controls and treatments	Procedures

The assessment at this time was as follows:

- Risk management was critical and underpinned the process
- Controls and treatments could not reduce residual risk to zero
- Emergency procedures were critical
- There were no procedures, plans or training for management in dealing with stakeholders in the event of a major incident.

Developing the Capability

Given that it is a combination of comprehensive risk management and effective emergency response capabilities that ultimately saves lives and property, Curragh made a conscious decision to assign a priority to the enhancement of it's existing emergency response capability at the mine. This was undertaken during the 1999 and 2000 and continues today.

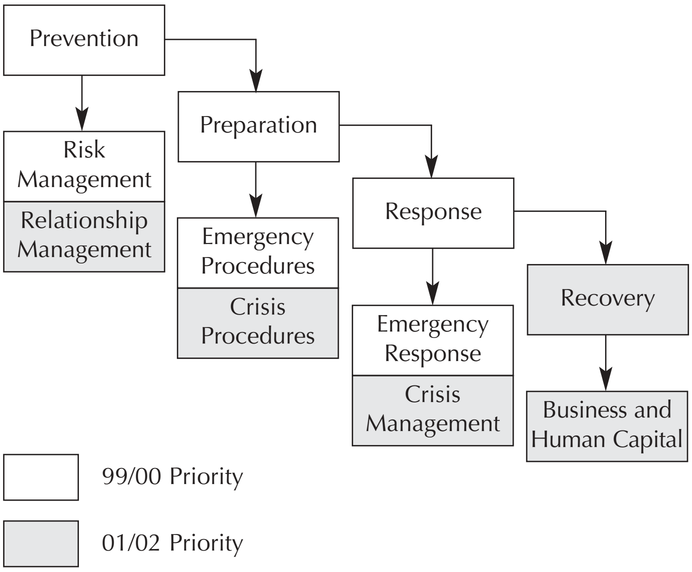
As the emergency response capability was enhanced it became evident that the next critical area that required attention was that of crisis management. Whilst the saving of lives was of paramount importance there was also emerging recognition that a major incident could also impact upon other important company assets such as reputation, key stakeholder relationships and employee morale all of which require protection and enhancement. In short, there was recognition at management level that it was not good enough to simply call the fire/rescue team and put the "fire" out. The company needed to inform stakeholders about it's cause, it's impact and what the company was doing about it. This theory would only work if the emergency and crisis plans were integrated and provided a seamless process. Disjointed messages and inconsistencies between actual events and the content of the communication would be a critical weakness for the company.

Development of the crisis management plan gained momentum during 2001 when a relationship was formed between Curragh and Rowland Communication Group, both of whom were members of the QMC Health and Safety Committee. At the time Curragh was investigating how to develop a crisis management system that would add value to and integrate with its existing emergency procedures. Rowland, a communication management firm, was able to provide specialist advice in the area of crisis communication, stakeholder relationships, media management and crisis simulation activities. The key challenge was integrating crisis preparedness into Curragh's existing system.

Curragh's challenge was to build a multi-layered capability that was "real" and not just theoretical. The capability needed to have substance - a framework, KPIs and be reportable. Without these elements Curragh's capability would be disjointed, lack cohesion and be difficult to resource, fund, evaluate and implement – a recipe for failure. In effect what Curragh did was to breakdown it's capability into component parts so that each could be further developed and integrated with the other components. By doing this Curragh was able to achieve both vertical and horizontal integration of the capability components. This process was undertaken intuitively and based on considerable experience, knowledge and a clear vision of the desired outcome. Rowland assisted Curragh by providing the formal structure for the process with particular input into the collective training capability.

The following diagram shows both the 99/00 model and the 01/02 model highlighting the areas in which crisis management was to be integrated with risk and emergency procedures.

Capability Development Flow Chart



As a result of this formalisation Curragh's capability was divided into six areas:

- **P**eople
- **O**rganisation
- **S**ustainment
- **T**raining
- **E**quipment
- **D**ocumentation.

The elements of Curragh's capability known as **POSTED** is based upon the concept of capability development used by the Australian Defence Force and is a key part of developing a "real" capability. It works by acknowledging that, to be effective, each component has specific requirements. The components are further explained as follows:

People - The people component requires not only having the right number of people but also having people with the appropriate skills and competencies.

Organisation - The organisation must be structured to allow the capability to be effectively implemented. The organisational structure must have the appropriate number of senior managers, workers, technical staff and administrative support personnel. The challenge is to ensure that the balance is right. An organisation that is too flat hierarchically may not support an effective command and control system during an emergency or crisis and similarly an overly hierarchical structure may not be responsive enough to deal with the immediacy of a situation.

Sustainment – A capability, particularly one that relates to the saving of lives, cannot be allowed to fall below an acceptable level at any time. Capability sustainment is obtained primarily through advanced planning. Planning for when people will be absent, up-skilling new team members and the procurement of new equipment etc will ensure that the capability is sustained. During an emergency or crisis, sustainment also refers to the ability to sustain a high level of the capability for an extended period of time. Rotations and rest of crews and team members is essential if the quality of response is to be maintained.

Training – Training is a fundamental platform for the development of capability. It is generally divided into individual and collective training. Individuals require training in skills that prepare them for being part of a larger group such as collective training which brings together individuals and prepares them to work together while utilising their individual skills. Training is expensive both in dollars and time and must be planned to ensure that the collective capability of the group or organisation is enhanced. An annual training calendar should be developed that ensures all aspects of the skill base are addressed.

Equipment – Equipment, like training, is fundamental to capability and is not just about what is on inventory. The condition and availability of the equipment is also important. Equipment requires regular inspection, maintenance and use if it is to properly perform its role in an emergency. Regular exercises should be designed to test the capabilities of equipment as well as providing familisation to fire/rescue personnel. Exercises will assist in highlighting deficiencies and the need for additional or updated equipment.

Documentation – Documentation is often a component that is overlooked as a key capability. Without adequate and up-to-date documentation the capability can be reduced. It is important that the system follows a natural hierarchy of policy and procedures. High level documents such as legislation, workplace health and safety guidelines, codes of practice and company policy should inform and guide lower level documents such as work instructions and emergency and crisis plans. Similarly, accurate and up-to-date records of training activities, both for individuals and groups, competencies, equipment maintenance etc fulfil a key part of the capability and must be maintained as they underpin and support the other components of capability. All training should be documented to prove due diligence.

Capability is determined through the assessment of all components. This process helps to identify the impact of a deficient component on the overall capability. The implementation of this system ensures that the organisation does not suffer from what can be referred to as "hollowness". Hollowness occurs when on face value the capability exists when in fact a key component does not meet predetermined levels of performance. Hollowness is often typified by having the right number of people but who lack the necessary skills or training. Some organisations have difficulty in firstly recognising the hollowness and secondly reporting it. Acceptance of hollowness is a poor risk management strategy. It can lead to loss of life/major equipment damage/production loss/damage to the company's reputation.

The steps in implementing the process are as follows:

1. Determine what capability is required by the organisation
2. Identify POSTED component levels required to meet capability
3. Set KPIs for POSTED to meet capability requirement
4. Determine resources required to meet KPIs
5. Develop component capabilities
6. Report and monitor.

Mock Exercise

Having prepared a crisis management manual, Curragh undertook a training and validation process in 2002. The aim was to validate Curragh's overall crisis management system of which the Crisis Plan was a key component. The objectives of the activity were as follows:

- Familiarise individuals with the system including the manual
- Up-skill individuals on crisis management techniques including decision making and information management
- Integrate Curragh crisis management with the Wesfarmers crisis management system
- Identify areas for improvement.

The mock exercise was preceded by:

- Crisis management training
- Media training
- Desktop exercise.

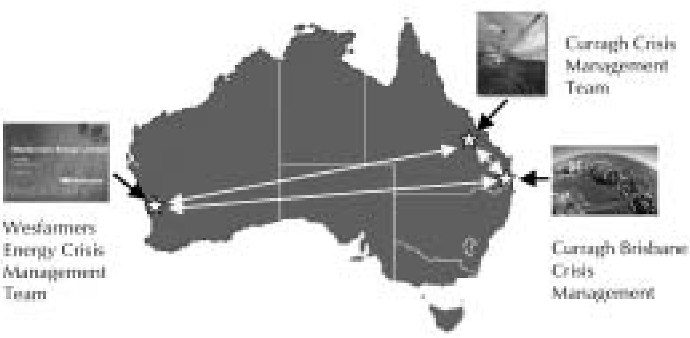
Mock Scenario

At 7.40am a portion of a high wall collapsed on several vehicles containing six workers. Initial reports indicated that there was one fatality, two workers seriously injured and three workers unaccounted for presumed trapped in the vehicles. The emergency response was triggered by a radio report from the Senior Health and Safety Co-ordinator which activated both the emergency and crisis response teams.

Exercise participants:

- Curragh
- Wesfarmers Energy – Perth
- Wesfarmers Curragh – Brisbane
- Curragh Coal Sales – Brisbane
- DNR&M – Rockhampton
- Police – Blackwater and Emerald
- QAS – Blackwater
- SES – Blackwater
- Industry Health and Safety Representative – Middlemount
- Blackwater Hospital
- Chubb Security – Emerald
- Blackwater Herald News
- Central Queensland News – Emerald
- Centacare counselling services – Blackwater and Emerald
- Minter Ellison – Legal firm Brisbane.

Communication Network



Critical Path Assessment

The involvement of these stakeholders was critical to the success of the activity. By involving the key players Curragh not only strengthened existing relationships but developed new ones. The involvement also allowed for the testing of what were identified as critical path activities. Three of these critical paths were:

1. **Medical evacuation and treatment.** This path was tested by ensuring the casualties were evacuated to the Blackwater Hospital for treatment. Additionally CAPCOM (Ambulance emergency communication centre) in Rockhampton provided real time information on the further medical evacuation of one of the casualties to Brisbane. This critical path tested communication, procedures, reporting and monitoring of personnel. It also required Curragh to allocate appropriate management personnel to visit the hospital to offer support.

2. **Notification of Next-Of-Kin (NOK).** One of the areas which is often paid lip service in exercises is that of the notification of the NOK. This important and sensitive event, whilst the responsibility of the Police in the instance of a fatality, requires significant attention by the company. To ensure that this part of the crisis plan was tested a NOK scenario was incorporated into the mock exercise. This involved a senior Wesfarmers manager in Brisbane to be physically in attendance, along with Police, when a NOK was notified that his son was involved with the incident and was missing. Following the notification the Brisbane office was required to provide support to the NOK and other family members in the form of arranging air line tickets, airport pick up, transport in central Queensland, accommodation and locating the NOK wife who was travelling overseas at the time.

3. **Corporate communications.** Consistency in information and the gaining of the appropriate approvals for its release was identified as a critical path which required evaluation. This was achieved by having the next two levels of crisis management play an active role in the exercise. Information was continually forwarded from Curragh to Brisbane and Perth throughout the exercise to provide awareness of the situation at the corporate level. Company policy requires that all external communication in this situation be approved by Wesfarmers Energy in Perth prior to release. The exercise controllers tracked the flow of information to ensure that only approved information was released throughout the exercise. This is a very important critical path and one that is traditionally not well tested in exercises.

Conduct of Exercise

While incidents tend to eventuate from a previously identified risk, they often come with little or no warning, so it would be inappropriate to test and evaluate the system with the emergency and crisis management teams fully prepared and "in their starting blocks". To ensure that any hollowness in the initial response could be identified the timing of the exercise was kept secret from all employees except for SSE and Senior Health and Safety Co-ordinator.

The exercise was designed to test both the emergency response and crisis management capabilities and focussed attention upon the integration of these two critical elements. Key players were brought in to the activity in order to reflect, as best as possible, the reality of the situation. Importantly key representatives from the Police, QAS and DNR&M were present and interacted fully with the emergency response personnel and the crisis management team members. Media interaction was a major part of the exercise with both real and role-playing media on-site throughout the day. Unlike traditional exercises where media play is post-processed and presented after the activity, media play in this exercise was presented in real time. This not only included hourly radio news updates but included a major TV news broadcast at around 1.30pm. By involving the media in this way the crisis management team was able to review its communication strategy and determine its effectiveness and make changes as necessary.

Debrief & Lessons Learnt

Exercises of this type provide tremendous benefit to the organisation. To capitalise on the investment, debriefs and reports are necessary to ensure that critical lessons are not only logged, but learnt. At the completion of the exercise a debrief with all players was conducted to capture immediate feedback on the activity. This information was subsequently combined with more formal feedback and delivered to Curragh in the form of a written report.

Recommendations contained in the report were divided into one of three areas:

- *Sustain* – Those policies, procedures, plans and actions that were deemed to be of an appropriate level
- *Improve* – Those policies, procedures, plans and actions that were deemed to require attention and enhancement if an acceptable level of competency is to be achieved in future
- *Fix* – Those policies, procedures, plans and actions that were deemed to be inadequate or absent and must be fixed if an acceptable level of competency is to be achieved in future.

The exercise provided many valuable lessons for Curragh and Wesfarmers. The key lessons included:

1. The importance of having a crisis plan that is fully integrated with the emergency response plans
2. The benefit of bringing all stakeholders together in a mock exercise which allows for the transfer of information amongst stakeholders and enhances the understanding of each other capabilities, procedures and requirements
3. The importance of having a capability development model such as POSTED to provide a framework for emergency and crisis management capability development.

Participants' Comments

As part of the exercise report comment was sought from external participants to gain a better understanding of their perceptions of the exercise. The following comments are indicative of the feedback.

Tom Kuzman – Managing Director Wesfarmers Curragh
Crisis management systems have been a demanding management task, but the national and international pressures have certainly moved it to a very high priority over recent times. I believe that Rowland's development and training programs have been very helpful and this has been significantly boosted by the recent mine-site mock exercise.

Bronwyn Murphy – Centacare
Inclusion in the Mock Exercise had significant learning value for Centacare. Lessons were learned by being on site and fully involved in the incident that may not have otherwise been possible if our role in the mock did not include a realistic response. Congratulations to Management for supporting the concept and to Rowland Communication Group for planning and implementing the mock exercise.

Pamela Sikora – Director of Nursing, Blackwater Hospital
To be invited to be a part of the exercise was most welcomed. It is important for the hospital to work closely with other agencies in a training situation so that should incidents like these occur we are well prepared. We don't have the luxury of second chances in our business and the mock exercise provided an excellent simulation for our team at the hospital. Both Curragh and Rowland should be congratulated for their efforts in making it happen.

Senior Constable Greg Dwyer – Blackwater Police
The exercise provided an excellent forum for Curragh personnel and other agencies to activate response procedures and genuinely interact in a simulated environment. During the exercise I noted that Curragh personnel were committed to achieving a positive outcome and responding to the requirements of other agencies and needs of affected individuals. I commend Curragh management for their commitment to developing effective crisis management procedures.

Conclusion

Over the past five years Curragh has devoted significant effort and resources to the establishment and maintenance of an effective emergency and crisis management capability. The partnership of Curragh and Rowland in developing the capability has been very successful. This success can be attributed to:

- Commitment from senior management
- Development of a clear capability definition
- An understanding of the role all elements of **POSTED** play in the capability development model
- Specialist input from Rowland Communication Group in specific areas such as exercises
- Adequate funding and resourcing fire /rescue team and modern equipment
- Adequate funding and resourcing of policy development and training
- A self imposed evaluation and exercise continuum.

The mock exercise was not the start of the capability development process nor was it the finish but rather an important part of the overall Curragh emergency and crisis management development process which is under continual review and enhancement. We hope and pray we never need to implement our processes for real!!

Evidence Shows Workplace Health Promotion Works - But How do you get your Employees to Attend?

Leanne Scanes, Corporate Bodies International Pty Ltd

Abstract

To ensure improved health, reduced absenteeism and increased productivity, it is essential health initiatives have a high participation rate. Choosing the most expensive and well designed initiative will not guarantee attendance. Voluntary unpaid participation outside work hours is often the greatest hurdle faced when trying to implement workplace health promotion.

The range of health initiatives available is ever increasing. Health screenings, pamphlets, toolbox talks, seminars, multi - session programs, employment of a health practitioner and building of gyms or sporting facilities all achieve varying degrees of participation. Even within the mining industry there is dispute over the most effective means of improving employee health.

Once an initiative has been selected the difficulty remains convincing employees to attend. An essential key is to know what attracts employees to a program. Initiatives which address topics relevant to the workforce, are fun, interactive and presented in an informal environment all achieve high attendance. One crucial factor in maintaining employees commitment to the program, is the presenter's ability to communicate the information with enthusiasm and generate ongoing adherence.

The elements which attract employees to participate in a health initiative and the characteristics pertinent to ensuring continued attendance are explored in this paper.

Introduction

It has been established that no organisation can remain productive without maintaining the health, job satisfaction and morale of its employees (1). When considering the costs of poor health to business, and its increasing relevance, it becomes evident that initiatives need to be taken to reduce the incidence of workplace accidents and injuries, and subsequent worker's compensation claims (2). Health promotion programs are not compulsory in Australia, however their popularity is growing.

There is increased recognition that Occupational Health and Safety (OH&S) legislation emphasises the need for a workplace to be not only safe, but also healthy. The majority of organisations are working to reduce workplace health hazards, such as exposure to noise, heat and dust. However the emerging trend is to go beyond this legislative requirement and offer health promotion initiatives to encourage employees to achieve optimal health.

At the 1993 Minesafe International Conference, Ric Charlton CEO of Shell Australia, asked "Should lifestyle and health promotion of the workforce be the employer responsibilities?" Ten years on, this question remains unanswered, although most companies are beginning to recognise the negative impact of poor health on business profitability, and the influence of an employee's lifestyle outside of work on their work performance.

Workplace health promotion activities are often separated from OH&S issues. However the question is: should they be addressed congruently? Employees are offered sunglasses, sunhats and sunscreen when working outdoors to prevent skin cancer. Should companies go one step further and offer skin cancer screening, or seminars on early detection of skin cancers as a further means of prevention? The rising implementation of health promotion programs is beginning to set a trend in which employers are taking more responsibility for the employees' health and well being, whereas the employee accepts less responsibility. Programs must empower individuals to accept responsibility for their own health and well being. Ric Charlton adds, "If we believe that health promotion in the workplace reduces accidents, it should be part of an overall effort to improve safety."(Ric Charlton CEO of Shell,1993 Minesafe conference).

While in support of the use of health promotion strategies to improve employee health, the concerns of unions, employees and governments is that employers may seek to improve productivity and moral in the workplace through high profile health promotion programs, at the expense of basic OH&S Issues(3).

The question over the responsibility of employers to offer health promotion will continue to be debated. However there is little argument to negate that these programs do provide very real benefits to the workplace(4). When used in conjunction with stringent OH&S standards the "two-pronged" approach to employee health results in a synergy that will maximise the positive outcome (3).

There is continuous acknowledgement that what employees do outside of work hours impacts on their health and productivity as much as activities done at work (4). Employers can justify the use of health promotion to assist workers to achieve better health and lifestyle habits. Adoption of primary care strategies that address the underlying issues of poor health results in benefits to all concerned: the workers, their families and the employer (5).

The short term benefits of running health promotion programs are difficult to measure, such as improved staff moral and improved employee/management relations (6). Another short term benefit is the organisation's improved public image by demonstrating a concern for the welfare of their employee base (7). This has a potential flow-on effect of improved staff recruitment and retention.

The importance of long term and financial benefits to measure success becomes more apparent as the program progresses. The three main financial concerns of most workplaces: productivity, running costs and staff turnover, can be abated with a successful health promotion program. Decreased absenteeism, improved productivity, improved fitness, reduced workers compensation claims and fewer retirements due to illness (6), are all known benefits of workplace health promotion.

Australia is behind the developed world when it comes to placing an increased emphasis on employee health. One possible reason is that Australian companies are not required to pay the health care costs of employees. Rather, most companies have their own policy regarding fitness and health requirements for employment. The majority of organisations in which employees undertake physical tasks require a pre-employment medical to ensure fitness for duty. However, many organisations lack ongoing monitoring of an employee's health and fitness during their time of employment. If pre-employment fitness is vital, the same importance should be placed on an employee's health throughout their employment. Anecdotal evidence, and simply looking around a worksite will reveal that this is not the case.

Corporate Bodies International, a provider of health and lifestyle programs to the mining, and other blue collar industries conducted a survey with two QLD coal mines in the Bowen Basin (one underground and one opencut) and a quarry in the ACT. After completion of the 'Working Bodies' program, a health and lifestyle program designed specifically for blue collar workers, 150 participants completed a questionnaire. Employees were asked for their reasons for joining the program. 46% said because their "waist line was expanding" and 43% reported they had gained weight over the past 5 years. Due to the small sample size it cannot be assumed this is a true indicator of the entire industry, however it does give an insight. This research is intended to alert companies to a possible issue occurring onsite that may require attention.

Many organisations report using health promotion in collaboration with an OH&S framework to improve employee health and well being. Mining and construction industries are much less likely to offer health promotion initiatives than white collar industries (4). Even when initiatives are offered they tend to be less intensive, whereby they do not achieve sustainable health and lifestyle change (4).

Blue collar industries, such as the mining industry, generally have a male dominated employee base. One of the most common beliefs is that men don't care about their health (8). However, people who work with men know that many more men care about their health than generally reported. Essentially there are many more reasons, other than apathy, that limit a man's ability to take steps to improve his health (8).

It is widely reported that blue collar workers (9) are the least healthy of all employment groups, and they are most likely to report to work unwell. Many employers are actively addressing this issue, as they recognise workers who are not fully functioning affect production and can become a safety hazard. Presenting for work on time every day and going home in one piece does not mean your workforce is healthy. Nor does a low absentee level indicate healthy employees(9). Lower productivity due to unwell workers may be more prolific that thought (9).

What is known about men, especially in regards to blue collar workers, is that they are less likely to participate when they view the health promotion strategy as something of no relevance to them. The failure of health programs to specifically address the needs of these working men has resulted in many drawing the conclusion that programs simply do not work with this group of the population. However, programs designed specifically for these workers, and presented with the right approach, result in a high degree of participation and measurable long term health benefits (10).

Many organisations are now introducing health promotion programs, with the aim to improve the health of every single worker, particularly those at high risk (7). The aim to have all employees attend a program can only be achieved by making it compulsory. The reality is that not all employees want to become healthier, and programs should be voluntary. Attendance alone does not ensure participants will change their current health and lifestyle behaviours (J).

To make a program compulsory, the employer must run the program in work time, thereby contributing financially to the cost of the program, and also bearing the costs of the resulting lost production. Two of the main benefits employers hope to achieve by running health promotion are increased production and improved morale. Running programs in work time will impact negatively on production schedules, and forced participation will only harm morale. Evidence shows that despite programs being run in work time 100% employee attendance is not guaranteed (11). Corporate Bodies International has experience in conducting workplace health promotion programs within blue collar industry, including the mining industry. Our research indicates those programs which are voluntary and run outside work time produce the greatest results. In addition, employees feel a sense of ownership over the program, as they are doing it in their own time, on a voluntary basis, and are less likely to question the company's motive for such promotion.

Program success is often incorrectly measured by participation level. However, the number of program attendants does not indicate the amount that actually made lifestyle change based on the recommendations made. It is also incorrect to use the drop out rate of the program as a measure of its ongoing success (or failure) as some initiatives, such as flu vaccinations do not require the time commitment as multi-session programs aimed at changing employees' established lifestyle habits. A program can be deemed successful when the majority of participants make sustainable lifestyle change. This is often the case in voluntary programs. If that program also attracted many employees, the outcome is amplified.

To illustrate the different scenarios that may result when running a health promotion program, we have considered a workforce of 200 people. Measuring success purely on level of participation would not give a true indication of employee health improvements. Figure 1 shows varying degrees of participation that may be achieved from the same health promotion program. A non compulsory program can still result in a high proportion of the workforce making lifestyle changes. Conversely, a program that attracts very few participants, even if all are highly compliant, will not create a dramatic improvement in the overall workplace.

No of participants	% of workforce	% who made changes	Number who made changes	Total % of workforce who have improved their health
20 staff	10	70%	14	7%
100 staff	50	50%	50	25%
200 staff (compulsory program)	100	20%	40	20%

Figure 1.0: Illustrates workforce participation is not the only determinate of program success.

Giving all employees the opportunity to participate in health promotion programs is often one of the greatest concerns for many employers. Evidence shows that those employees who are already fit and healthy are most likely to join, while those with the greatest need are less likely to participate (7). Men are even more notorious for this, as most men view their health as much better than it actually is (9), only requesting help when their health problems are of an acute nature.

Participation in workplace health promotion programs has been widely studied in Australia and throughout the world. Research indicates that people with a higher degree of education, who play sport, have strong family support, perceive their lives as stressful, and are only slightly overweight are most likely to participate (7). Young men, and smokers of any gender are the least likely to participate in health promotion programs run at the workplace. Surprisingly for many researchers, men who choose to participate in health promotion tend to be older and overweight (7). This is particularly important to the mining industry, who face the challenges of an aging workforce(12). The knowledge that overweight, older men are more likely to participate improves the chance for lifestyle change to occur in this population group. If health promotion can help combat the problems associated with aging workers, pro-activity in the area of disease prevention should be included in any strategy to improve staff retention.

The challenge remaining is deciding which method encourages employees to voluntarily participate in a workplace health promotion program, outside work hours, for which they are not being paid. Remuneration or incentives are possible, however when the aim is to reduce costs and maximise profitability this may defeat the purpose of running the health promotion program. More importantly it will not increase the chance of long term compliance with the concepts taught.

Companies interested in implementing workplace health promotion programs must also choose between an in-house program run by a staff member, or using an outside consultant. The former option is not always the simplest and most cost effective solution. Implementing programs run by an outside consultant ensures a professional and evidence-based approach, and reduces labour costs. Corporate Bodies International is just one organisation running health programs, with proven long term results, that are achieving participating rates of around 50% of the workforce.

Management and employee support, a realistic time commitment and creative marketing are a number of ways to increase voluntary participation in your workplace health program.

1. Get Support & Involvement from Management

One key benefit of health promotion programs is the resulting improvement in employee/management relationships (6). The organisational structure of the company also affects the participation levels of employees (4). Those programs that are seen to be supported by supervisors and management have better attendance (7,4). Support by management is often seen by employees as a sign of approval and indicates the value of the program. The belief the program is worthwhile is further enhanced when managers make the decision to enrol and attend with employees (7).

STEP 1 – MANAGERS MUST SHOW THEIR SUPPORT BY PARTICIPATING

2. Involve Employees in the Decision Making Process

Management support alone does not guarantee employee attendance (5). An effective way to show employees their opinions are valued is to involve them in decision making, especially when the decision to be made is for their benefit. Involving employees in aspects of program planning or selection will initiate improved relations in the workplace, and spark motivation and participation (5, 13). Employee involvement in decision-making also ensures the program provides the information and skills employees require (4).

Most companies have OHS committees which are represented by a variety of employees and management. This is essentially the best forum in which to discuss the possibility of running workplace health promotion programs. It is impossible to tell every employee about all possible ideas and plans, but a committee that is representative of the entire workforce provides an avenue for information to filter through to all workers. Listen to the committee and choose a program that addresses topics they believe their colleagues are interested in. The members of the OH&S committee who are in support of the program then become ambassadors, and can enthuse and motivate other workers to join (5).

STEP 2 – CONSULT WITH EMPLOYEES AS YOU CHOOSE A PROGRAM

3. Choose a Program that Addresses Topics People are Interested in

As discussed asking employees what topics most interest them is a great way to ensure your program has the greatest chance of high attendance(14). If management alone decide to introduce a program they think is worthwhile, the people you want to attend may not share the same interests. This is confirmed with some evidence showing blue collar and white collar workers often want to know about different topics (10). By no means can you cover every health topic that your staff show interest in, but covering topics that are most popular will increase the appeal of your program.

The aforementioned survey by Corporate Bodies International asked mining employees the topics they would most like to know about if attending a health promotion program. The average age of those surveyed was 30-39 or 40-49, which is fairly indicative of the age of employees in the mining industry in Queensland. From a list of 11 topics, participants were asked to select the three of most interest to them; please refer to results in Table 2.

The most popular topics were "healthy lifestyles" (81%), "weight loss" and "heart health" (58% each). Surprisingly, just 7% rated free gym memberships as a preferred way to improve their current health. This contradicts the view that many worksites have in regards to free gym memberships being the best health promotion initiative.

Topic	*% in top three*
Healthy lifestyles	81
Weight loss	58
Heart health	58
Nutrition	52
Stress management	15
Exercise	12
Emotional	7
Gym memberships	7
Weight gain	6
Quit smoking	4
Relationships	0

Table 2. What three topics most interest you.

Research in Australia and abroad investigating the most popular health topics in industries other than mining are parallel with our findings (13). Nutrition, weight loss and exercise initiatives were those selected as the most likely programs employees would volunteer to attend (13). White collar workers rated stress management much higher than blue collar workers (13),however, stress was still a topic of interest for those employed in blue collar industry.

When debating who is responsible for an employee's health (ie. the employer or the worker), discussion often shifts to why employees don't take the initiative themselves to improve their health. Program participants were also asked for reasons they had not proactively attended similar programs. Over 51% of those surveyed reported on lack of availability in their town. Therefore if the program is new and exciting, and covers the topics they are interested in, employees are more likely to attend.

STEP 3 – CHOOSE A PROGRAM INCORPORATING INFORMATION OF MOST INTEREST TO YOU EMPLOYEES

4. Consider whether Programs should Involve Families/the Community

As previously discussed high attendance rates do not lead to improved productivity, improved health and moral. It is change in health and lifestyle that creates change in the work environment. Those people that achieve the greatest results are those that have support to make changes both inside and outside of work (10). This support is essential for long term success. Allowing spouses to attend the program can increase the number of employees who also attend. Setting guidelines that spouses can only attend if their employed partner does can lead to encouragement from the family for attendance. This further enhances the number of your employees who may attend.

In the experience of Corporate Bodies International, spouses are interested in attending for their own benefit, as well as to provide encouragement and support to their partner. This translates into not just fitter, stronger and healthier employees, but also happier people in the short and long term. Also, if the families of the employee are responsible for the cooking and shopping, and the program focuses on improved eating habits, it seems foolish not to include those who prepare the meals in the education. One of the greatest criticism shiftworkers have of their lifestyle is the inability to spend time with their families. This is an initiative, if offered to families, that could help them spend time together, while learning and improving their health.

In many remote areas where it is difficult to attract young families to the area, these initiatives can provide services that they otherwise have minimal access to in small towns. This will strengthen community ties and reinforce that the employer cares for the well being of its staff and their families.

STEP 4 – CONSIDER INCLUDING SPOUSES IN THE PROGRAM

5. Set a Program Structure to best meet Employee Needs

Once you have selected a health promotion idea, it is important to decide on an appropriate time length for the program. Programs must be of sufficient length to achieve long term health improvements in employees (5). If the program is to be run in the employees own time it must be of realistic length. Programs requiring a large time commitment will not attract employees (14), whereas those with a short time commitment spread over a period of time attract a higher participation rate (4).

Some initiatives only require a very short period of time, while others, to be effective, do require a longer time commitment on the employees' behalf. An initiative such as free flu vaccinations may attract 80% of the workforce, however, how many people would choose to have the flu shot if they needed a booster every week for the next six months? Similarly, a one-hour session to teach people how to lose weight is not going to be particularly effective. Expecting your employees to give up too much time will turn many people away from participating (7), and not enough time with effect the participants' motivation for long term success (3).

Programs with flexibility to allow participants the option of time to attend will initiate much wider attendance (19). Working in shifts is often the greatest barrier people express when asked why they don't take care of themselves. When questioned as part of our survey as to why participants had not attended similar initiatives when available, 30% of respondents said working in shifts was the main reason, with 25% saying lack of time was the biggest barrier. Equal accessibility for all staff should be paramount; this may require multiple sessions at various time-slots to capture everyone. This is often where hiring an outside consultant to devote the required hours to the initiative will increase the likelihood that, logistically, all staff will have equal access.

STEP 5 – CHOOSE A SUITABLE TIME FRAME AND PROGRAM STRUCTURE

6. Effective Marketing

You have selected a program in consultation with employees that is supported by management; you have decided whether to include families, and discussed a suitable structure and time frame for the program. The only thing left to do is to tell everyone what it is about and wait for people to sign up. Which sounds a lot easier than it is. The most common mistake most companies make is devoting their entire budget to running the program. You must devote adequate time, money and effort to advertise the program (4). No one wants to be the first to enrol and no one wants to enrol unless they fully understand what they are committing to.

Be completely open and honest with your staff when they question your motive for running the program (5). Often in workplaces with poor management employee relations, misinformed workers will often hold a negative view on health promotion programs. Rather than seeing it as a way for their health to be improved it will be viewed as a way to determine who is the fittest and healthiest, and a means to get rid of the unhealthy people. Using an outside consultant often overcomes this barrier especially when the consultant assures participants any health measurements taken will remain entirely confidential (5).

The use of repeat promotions and multiple communication channels to advertise the program will not only ensure you reach all employees, it will also reinforce the program to staff (4). Many people move through the stages of change before deciding to commit. Often we see something once and think about it, see something twice and decide to do it, but it may take the third time before we actually do it.

(I) Market the Program as a Means to Improve your Health and Learn Something New.

People often have differing opinions as to why some people join programs and others don't. The reality is some people want to improve their health and others don't. If someone does not want to improve their health, they see no reason to join a health promotion program.

The survey by Corporate Bodies International asked participants for their main reasons for joining the program. 90% said one reason they joined was to improve their health, followed by 29% who said a reason they joined was they were curious and wanted to learn something. (See Table 3). 34% joined the program as it was at no cost to them, apart from their time.

Reason	***% to which this was important***
Improve health	90
Company funded	34
Curious – wanting to learn	29
Able to attend despite shifts	18
Participate with workmates	16
Attractive presenter	12
Group learning	11
Sounded fun	7
Past success of comp	3
Forced to attend	1

Table 3. Main Reasons you joined the program.

In a survey of several different worksites 80% of men felt the gender of the presenter made no difference to their decision to join (4). While only 12% of those surveyed by Corporate Bodies reported the presenter's looks made a difference to them joining the program. The strong comment made though was if the presenter looked healthy they were more likely to attend – as they would know the presenter was able to live what they were teaching.

MARKETING TIPS
– SHOW PARTICIPANTS HOW THE PROGRAM CAN IMPROVE THEIR HEALTH
– CHOOSE A PRESENTER WHO IS FIT AND HEALTHY

(II) Market the Program Shortly Before it Starts

Before you even begin to market your program, you must have some idea of when you plan to start it. It is no good decided to start when people sign up, as often people will not sign up until they are fully informed. While an exact date is not necessary a particular time frame is.

If you market the health promotion initiate to long before you actually plan to start, you risk two things(4). Firstly, participants won't sign up believing they can do it later or closer to the starting date. Secondly those that do sign up may change their mind and pull out before the start date, or forget altogether they actually enrolled(4).

You want to start your program while people are motivated and enthusiastic, and ready to make changes. Rather than later when the motivation and enthusiasm have fallen away.

MARKETING TIPS
– DON'T BEGIN MARKETING YOUR PROGRAM UNTIL YOU KNOW WHEN IT WILL START
*– START YOUR MARKETING CLOSE THE ST*ART DATE

(III) Use a Catchy Name for the Program

With health promotion simple small changes make all the difference to someone's health. It is the same with health promotion marketing. Simple things such as what name to give your program make a huge difference(5). Calling your company health program – 'the company health program' does not excite or enthuse people. You want people to be interested when they hear about the program and have a desire to find out more about it. If using an outside consultant generally the name of their program has been chosen and researched to show it excites employees.

As an example, a health consultant was wishing to provide employees with information regarding nutrition and shiftwork(5). This was initiated by writing a serious of articles on nutrition and cancer, and nutrition and heart disease. If was found very few people expressed an interest in learning more. When the name was changed to relate more to the target employees the participation rate improved dramatically (5).

MARKETING TIP
– CHOOSE A GOOD NAME FOR YOUR PROGRAM

If your program has the support of management, is developed or selected in consultation with your workers, meets their needs, is structured in the right way and run at many times of the day your program has a greater chance of attracting voluntary participation. The marketing of your program is crucial – devote time and money to this and you will increase employee enrolment.

The success of a program is not just reliant on getting people to attend, but their continued attendance. The question will always be raised as to why some people choose to drop out of health promotion programs while others keep on attending. Poor attrition can not only negatively impact on that particular health promotion program but also on the chance that any other programs will be run in the future.

When we asked participants for their main reasons that influenced their decision to return each week, the over whelming responses where because their health was improving (71%) and because they were learning something new (64%). Followed closely by to keep motivated (36%) and the program presenter (33%). Only 3% of people continued attending because they felt they had to. You do not want to promote an environment whereby people only attend each week because they are being forced to or feel they have to. This may show your program had low attrition, however it is unlikely these people will make any sort of lifestyle changes, especially those they will retain in the long term.

Reason	***% reported this as a reason for attendance***
Their health was improving	71
Learning something each week	64
Information was relevant to me	45
To keep motivated	36
Motivating presenter	33
Having fun	13
Time with workmates	6
Feel they have to attend	3

Table 4. Reasons why participants continue to attend each week.

This small survey along with other information on participants feedback of other programs across the world, where the general consensus is the same(5), gives several clear strategies that can be incorporated into a program to minimise attrition.

1. Measure Success in Many Different Ways

It is classic human nature to want praise for a job well done. When it comes to health improvement it is essentially the same. Thus, it is not surprising this was one of the main reasons those surveyed stated as a reason for continued attendance.

Companies who run health promotion expect to be able to show at the end that it worked – their must be some measure of achievement or otherwise management begin to wonder why they are even funding such initiatives.

This is equally true of individuals. If health promotion is run with no real way to measure success, or no emphasis on improvements then people are likely to wonder what good there is attending each week(4). Positive reinforcement of change no matter how small it is works(10). Participants especially those in nutrition and healthy lifestyle programs often fall into the trap of doing it purely to lose weight, when there are so many other health improvements that result from eating better and being more active.

What measurements to take will depend entirely on the health promotion initiative you are undertaking and essentially what the aim of the program is. Not everyone will improve their health in an equal fashion, so importantly ensure there are a number of different indicators/ measures of progress(5). This will allow those who improve in one area a sense of achievement and those who improve in another area to feel they are achieving something also.

The taking of measurements is one way to also increase support and involvement from families. If participants are given measurable evidence they can share with their spouses/families as to their improved health this will lead to further encouragement at home. This continued outside work support will increase the likelihood that changes will be maintained for a longer period of time.

MEASURE PROGRESS USING MANY DIFFERENT INDICATORS

2. Teach Participants Something New

As previously discussed it is important employees are involved in the decision making process, of choosing which health promotion program to run on site. If the selected program is that which most employees felt they would like to know more about, then ensuring they are learning during the program should not represent a large problem.

If people feel they are attending a program and not learning anything new, or not being taught what the marketing promised, then they are more likely to drop out. No one will willingly continue to spend their precious time in an environment they feel is not fulfilling. Even if the information presented is common knowledge, presenting it in a different matter, can reinforce it more clearly(A). By completing each session with an insight into what they will learn the following week, is also a good incentive for participants to return(5).

PRESENT INFORMATION IN A NEW LIGHT

3. Make the Information Relevant

Not only do participants want to increase their knowledge and awareness of how to improve their health they want to know how it relates to them, and how to put in into practice. If health promotion is done in a lecture style fashion, whereby participants are told what to and what not to do, they are unlikely to keep attending and even less likely to put it into practice.

People want to hear news they can use. There are three simple steps to learning (5). Listen and forget, see and remember, do and understand(5). If the information is presented with suggestions of how to put in into practice around current lifestyles and work requirements, participants feel it is relevant to them. With over 40% of those surveyed reporting the relevance of the information was a reason they kept attending our program, it is a major contributing factor to attrition.

MAKE THE INFORMATION RELEVANT BY GIVING PRACTICAL ADVICE

4. Choose the Right Program Presenter

Often occupational health and safety staff within the company have been used to advise workers on ways to improve their health such as how to lose weight or reduce cholesterol (15). However, due to familiarity and limited ability to run a comprehensive program there is generally little or no significant change in the behaviour of the individual (16). Never underestimate the impact the presenter has. There is a large financial and time commitment to investigate and run health promotion programs, sourcing a good program presented aids in high attendance levels throughout the program.

When a professional health provider is outsourced, there is greater likelihood, that beneficial changes in health behaviour will occur (17). When you are expecting your employees to turn up week after week, the program presenter needs to have rapport with the group. Strong inter-personal skills, excellent verbal communication, sensitivity to the needs of the group and the individual, as well as the ability to relate to your employees are contributing factors that motivate participants to continue attending (18).

CHOOSE THE RIGHT PROGRAM PRESENTER

Participant retention during the running of the program, alongside a high initial enrolment rate, enhances the chance of a large proportion of the workforce making health improvements. Multi-session programs are designed to teach employees many differing ways to improve their health. If participants attend all sessions of multi-component programs they are more likely to be able to select those components of the program they feel are easy to incorporate into their current lifestyle.

Conclusion

Well designed and run health promotion programs work. There are few who have participated in such programs who will disagree. Improved moral, better staff management relations, decreased workers compensation costs/claims and reduced absenteeism, these are all very real benefits.

It is frustrating that even the best planned and designed programs do not elicit 100% attendance. Any program that results in health improvements in individuals must be viewed as a success. Management support and involvement, along side employee decision making increases your chance the program will be well attended. By establishing a program structure suitable to the workers, run at times they can attend, which addresses topics they are interested in can only further enhance program enrolment.

Individuals have the ultimate decision of whether or not they want to improve their health. Employers and workplace health promotion programs have the ability to empower individuals to make changes, and offer avenues through which participants learn how to implement changes. Get your employees to voluntarily attend health promotion programs in their own time, and the battle is half over. The desire to change though remains with the individual. We cannot force people to attend, nor can we expect everyone to value their health in a positive light. As employers you can provide the water, make it appealing, lead the horse to it, but you cannot force the horse to drink.

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The Implementation of Common Health Standards across Multiple Mining Operations & an Example of Practical Application

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Abstract

Rio Tinto, one of the world's largest mining and mineral processing companies, has developed occupational health (OH) Standards as minimum requirements for all of its managed operations world wide. The OH Standards are a core element of the Rio Tinto occupational health strategy. They are due for adoption in 2003 and full implementation is expected by 2005. This means that we (Pacific Coal Pty Ltd) must have these standards fully implemented by the end of 2004, across all four operating sites (Blair Athol, Kestrel, Tarong, and Hail Creek).

This has raised a number of challenges for us, but already we have been able to demonstrate results at an operational level that translate into improved business performance.

This paper examines briefly what those challenges are and how we are going about ensuring successful implementation i.e. "successful" both in terms of:

- Meeting our compliance requirements, and
- Ensuring that we will get, and continue to do so over time, real value from the exercise at each of our operations.

The paper includes some background to the OH standards, outlines the process we followed to ensure that they would be implemented as required, and identifies key learnings from the exercise – mistakes, critical factors, and those things done particularly well.

To demonstrate how these translate into results at an operational level, a case study that deals with the implementation of OH Standard B3 - "Manual Handling and Vibration" is reviewed:

- What is required to make it work, and
- The value we are beginning to get from it.

Introduction

We (Pacific Coal Pty Ltd) recognise that excellence in managing our health, safety and environmental responsibilities is essential to any long-term success. This is the basis on which our OH standards have been developed.

We believe that soundly based standards, with performance against them being verified by both the business operation and Rio Tinto corporate, will achieve a step change in occupational health awareness and performance. The Rio Tinto OH standards were developed to represent best international practice. The intent was to begin a process to improve our performance to that of the best industries, rather than the best in the mining industry.

The intent of the standards is that we can demonstrate that it:

- Builds from compliance with applicable OH laws and regulations, to work in advance of routine industry standards, and
- Takes reasonable and effective actions to reduce adverse exposures as scientific knowledge changes – and often in advance of legal requirements.

This latter is particularly important for diseases with long lag times of 10 to 30 years.

Challenges

There were a number challenges for our business in implementing these standards.

Previous experience with implementation of Rio Tinto safety standards indicated that this exercise was going to require the allocation of significant resources – people, dollars and time.

- We wanted concise and precise auditable standards, but we also wanted guidance on how to meet the standards effectively and cost efficiently
- We were concerned that the timeframe we had been set to have the standards implemented would necessitate a higher cost than had been planned for in resourcing the right skills, and enough manpower, to meet the deadlines set.
- We also needed to improve interchange of information and expertise between the health services of isolated sites
- Previous implementation of the safety standards had been done on a site-by-site basis – we needed to eliminate the unnecessary duplication of work, but still meet the timeframe set, therefore necessitating parallel timeframes for work on the different sites
- We needed to ensure that our line managers had ownership of these standards – this was a critical factor in determining whether or not we would see real benefits from this exercise. To ensure that they had a basic understanding of the standards and why they are important, we needed to make the standards relevant to their every day work.

Structure & Scope of the OH Standards

The Rio Tinto OH standards reflect common industry issues. They contain two sections:

Section A - management system standards:

A1. General Health Systems
A2. Risk Management
A3. Workplace Monitoring
A4. Medical and First Aid Treatment
A5. Occupational Medical Surveillance
A6. Records

Section B - performance standards:

B1. Particulate and Gas Exposures
B2. Hearing Conservation
B3. Manual Handling and Vibration
B4. Hazardous Substances
B5. Radiation
B6. Thermal Stress
B7. Fitness for Work
B8. Legionnaires Disease
B9. Travel and Remote Site Health
B10. Occupational Exposure Limits

The principles behind the management standards (Section A) are that each site must have a documented assessment of their health risks (qualitative in the first instance, and quantitative if deemed necessary); and systems or processes in place to:

- Quantify, where necessary, exposures to a statistically valid degree
- Manage identified risks
- Be able to ensure workers are fit for their work
- Recognise any diseases that might develop; and
- Maintain records of exposures and medical examinations.

Section B contains specific performance standards relating to prevention of diseases such as deafness, silicosis, musculo-skeletal harm, white finger and legionnaires. Generally, these standards are set at best international practice.

Development of OH Standards

Rio Tinto developed a common set of safety standards over a 2-year period between1998 and 2000, and these were then implemented worldwide across the Rio Tinto businesses. The implementation of these standards has achieved a culture change across the Group.

Occupational health performance - measured in terms of reported numbers of new cases per 10,000 employees - had been reported annually since 1997. Measured performance did not show continuous improvement. Hence, the charge was to develop a similar set of standards for occupational health. Development of draft Rio Tinto OH standards commenced in early 2000.

The first draft of the OH standards caused considerable concern. It had been assumed that occupational health principles were universal and therefore, the initial text had been written by the corporate HSE group with no consultation. This initial draft had also tried to blend standards with guidance on how to achieve them. These were mistakes. Other concerns were the perceived resources required to implement them, particularly as the safety standards were consuming more resources than originally anticipated.

Recovery of the situation was by a series of regional workshops at which managing directors and sites' health professionals were invited to comment on the text. From these meetings a significantly different draft was developed, shorter and composed of precise, auditable standards. This step was essential to the long-term success of this exercise. It allowed the key stakeholders in the various Rio Tinto group businesses (managing directors and sites' health professionals) to develop a pre-requisite level of ownership and understanding of the OH standards, as well as an understanding of the types and level of resources that would need to be allocated.

Concerns for adequacy of resources for implementation was addressed by extending the timeframe available for implementation.

An additional action, which proved to be of real value, was that much of the material removed from the initial draft of the OH standards was used as the basis for occupational health information and guidelines (OHIGs). The draft standards and OHIGs were placed on the company intranet to improve interchange of information and expertise between the sites.

A final version of the OH standards - deemed auditable and credible by the businesses - was agreed by the end of 2002. Although group businesses formally began implementation of the OH standards from the beginning of 2003, in some businesses this process was already well underway (the work being based on the draft version of the final OH standards). Pacific Coal is one of those businesses.

Implementation of Standards

At a Rio Tinto level, a compliance assessment process for the OH standards has commenced (2nd quarter 2003), integrated with the current business and corporate HSE audit and review programmes.

All Rio Tinto managed businesses are required to be in full compliance with the OH standards by the end of 2004.

For Pacific Coal, implementation of these standards began way back in early 2001, when our managing director and site health professionals were invited to make comment on the original version of the standards. Our people had spent the time required up front to understand the potential impact (both in terms of "do nothing", and the practical aspects of applying them in the workplace) and resource requirements of the proposed standards, as well as establishing where the benefits for our business lay. This allowed them to help drive the review process and influence the final outcome. There are two important results from this process:

- A high level of ownership and working knowledge of the standards, and
- A set of standards that are able to be applied at an operational

level, without ridiculous restrictions that are the result of theoretically valid but highly impractical 'rules'.

Implementation of the standards has begun in earnest at Pacific Coal. We have made a number of decisions that are assisting us in minimising the resources we need to allocate to this body of work, while still keeping to the timeframe allocated.

- We are combining the OH and S standards at a Pacific Coal level, to eliminate unnecessary duplication of common systems. (Section A of both the OH and safety standards are very closely aligned)
- Section A of the standards (management systems) is being implemented using a resource at corporate level, while Section B of the standards is being implemented at a site level, using common templates developed in conjunction with external OH consultants with the requisite specialist skills (e.g. SIMTARS)
- We have made a deliberate decision not to start with a blank sheet of paper – we are working very closely with the Rio Tinto HSE group, and other Australian Rio Tinto businesses, to ensure that where-ever possible and practical, we are using what others have developed as an initial draft in areas where we haven't done the work, and sharing what we have done in those areas we have.

A summary of the process we have used is as follows:

- Operational GM's are accountable for the standards being implemented at each of their sites
- Corporate OHS Manager accountable for managing the implementation project
- Baseline risk assessments for each of our sites
- Prioritising areas for action
- Developing action plans (at site and corporate level) and coordinating the sites efforts so that we do not duplicate the work
- Separating action plans for sections A and B of the standards
- Review our progress regularly
- Once initial actions have been completed, re-do risk assessment – document successes and areas for improvement
- Repeat the "plan – do – review" process.

Absolutely critical to this process being successful is the "review our progress regularly" – it ensures the input of sufficient levels of focus and effort. This takes the form of both internal progress reports, and a "verification audit" to be carried out by members of the Rio Tinto HSE team (the first having been scheduled for November this year).

So how does this translate into results at an operational level? A case study that deals with the implementation of OH Standard B3 – "Manual Handling and Vibration" is used to demonstrate the results we are seeing in our workplaces.

Musculo-skeletal disease (MSD) incorporates a group of conditions commonly reported within the mining industry. The decision was made that OH standard B3 needed to focus on the main causes of MSD within Rio Tinto: vibration and manual handling.

MSD has one of the highest incident rates of occupational disease within Rio Tinto, with musculo-skeletal incidence rates per 10,000 employees ranging from 20 to 80.

This group of conditions varies from back pain, an increasing problem in heavy equipment operators as increasing age and body weight become issues, to the effects of repetitive movements from jobs as varied as secretary and maintenance fitter.

Translation into Results at an Operational Level

We needed to ensure that our line managers had ownership of these standards – this was a critical factor in determining whether or not we would see real benefits from this exercise. To ensure that they had a basic understanding of the standards and why they are important, we needed to make the standards relevant to their every day work.

This case study helps to demonstrate how we are achieving this.

Manual Handling

Each of our operating sites has a requirement to reduce the number of Lost Time Injuries (LTI) incurred by 50% per annum, and combined LTI and Medical Treatment Cases (MTC) by 25% per annum.

At one of our sites, some basic analysis showed that 70% of the injuries incurred were sprains and strains. Turnover in the workforce is low, so it is ageing, and typically carrying old injuries. Hence conventional manual handling and ergonomics training was not being effective

The decision was made to put into place on site a Manual Handling programme, which was expected to have a significant positive impact on:

- Soft tissue injury reoccurrence
- Wanagement of 'old' injuries
- Workplace design improvements
- Workforce knowledge base.

The programme focus was at 3 levels: site, team, and individual.

At a site level the focus was on improving the site standard for manual handling and ergonomics. An Occupational Therapist was employed full-time on site (we recognised that we needed to allocate appropriate resource levels if we want positive, long term results in our health performance).

At team level, the focus was on implementing the programme based on a risk-based schedule – highest risk team first. The programme included:

- Analysis of team statistics
- Observations in the workplace
- Training for the team
- Changes to the workplace, tooling and work practices
- Detailed feedback to the teams.

The work for this programme was carried out over periods of weeks for each workplace. The occupational therapist was in the workplace everyday, taking photos, speaking with personnel, coaching and explaining. Changes were made in consultation with the personnel in the workplace. Success was measured by the adoption of healthier workplaces, work practices and tooling – not just in injury statistics. These factors were important in determining the programmes success.

At an individual level, the focus was to identify those that were most at risk (current or 'old' injuries, physical condition, work activities) and engage in personal coaching from the specialist Occupational Therapist e.g. exercise regimes.

The results of this programme were measurable and notable. They are summarised as follows:

Year	***LTI's due to sprains and strains***
2000	9
2001	7
2002	3
2003 to date	1

Through the process we used to implement this programme, we were able to demonstrate to our people that there was real value in the practical application of 'better' manual handling and ergonomics – to the way in which they did their work, not just their health and safety performance statistics. The level of ownership for the changes made means that they are far more likely to be sustained over time, and therefore have ongoing benefits to both the individuals and Pacific Coal overall.

Summary

There is a requirement for Pacific Coal to implement the Rio Tinto OH standards by the end of 2004. These were developed over a 2-year period with significant input from site OHS professionals and senior line managers. The OH standards are a core element of Rio Tinto's occupational health strategy, and are designed to be ahead of industry and legislative requirements.

The challenge faced by PCPL is to successfully implement these standards at an operational level, and in the process ensuring that we get, and continue to do so over time, real value from the exercise at each of our operations. We have done this by being involved in development of the standards at the earliest opportunity, by planning not to duplicate any work unnecessarily, and by ensuring that we could demonstrate real benefits through practical application at an operational level early on. The case study presented shows that there are measurable benefits.

National Industry Perspectives on Occupational Health Issues

Noel Wendt, Roche Mining, MCA Health Working Group

Safety and health is the number one priority of the Minerals Council of Australia (MCA). In pursuit of its vision of an Australian minerals industry free of fatalities, injuries and diseases, the MCA implements a comprehensive work program with a focus on leadership, recognition, performance measurement and reporting, identifying best practice and promoting continuous improvement.

The MCA through its Safety and Health Committee encourages and facilitates the Australian minerals industry achieve excellence in safety and health performance and its terms of reference are to:

- Identify and prioritise industry safety and health issues
- Develop and implement a Council safety and health policy and action plan to address priority issues and to support the Council's safety and health leadership role
- Recognise safety and health excellence achieved by the industry
- Provide timely and relevant information on safety and health performance and safety and health improvement initiatives
- Foster the safety and health initiatives developed through the Committee and the Council into the minerals industry
- Promote the safety and health achievements of the industry to the community
- Examine and report on such matters as may be requested by the MCA Executive Committee
- Provide representation, as appropriate, to other bodies on safety and health issues on behalf of the Council.

In 2002, recognising that the primary focus of the MCA safety and health leadership program had been on safety and the elimination of fatalities and injuries, the MCA agreed that a key future priority would be to increase the profile given to health issues.

Key reasons for a focus on health included:

- The lack of comprehensive and consistent data across the industry
- The difficulty in tracking the health of individuals moving between jurisdictions, companies and industries
- The long latency periods associated with some illnesses
- The difficulty in establishing causation due to masking by community health, lifestyle and other factors.

Previous work by the MCA had indicated health issues could be categorised into four distinct groups:

- Issues of potentially high consequence with long periods of latency, which from the incidence of cases appear to be under control – cancers, respiratory diseases associated with exposure to substances such as silica, asbestos and coal dust
- Traditional health issues for which there are interventions known to be effective but which may not be implemented consistently – noise induced hearing loss, exposure to hazardous substances
- Traditional health issues for which there are interventions known to be effective and which are generally quite well implemented – heat illness from exposure to heat, sunlight, and humidity
- Multi-factorial issues requiring new interventions – fatigue/fitness for duty, occupational stress.

An attempt to prioritise health priorities was limited by the availability of comprehensive and consistent data and the need to rely on anecdotal information.

To give impetus to the MCA's focus on health, a Health Working Group has been established to identify the key health risks in the minerals sector, provide advice on the most practical guidance available in addressing these risks and explore a possible framework for the ongoing monitoring and reporting of health performance within the minerals industry.

The key elements of the Health Working Group's plan of action are to:

- Survey available data collections on the health of workers – the intention is to build a compendium of the important sources of health data for workers in the minerals industry, including an indication of the data collected and any key findings based an analysis of specific data sets. The data bases to be surveyed will include relevant regulatory agencies and workers compensation bodies in WA, Queensland and NSW, the National Occupational Health and Safety Commission as well as company data
- Identify the different approaches to health risk assessment and the tools currently available or under development – It is considered important to determine how health risks can be given adequate attention within an overall risk assessment process and identify how chronic health effects can be rated compared to traumatic injuries
- Collate available data on the known health risks in the industry

and on the existing controls used to eliminate/minimise health risks - The initial health issues to be the focus of the Health Working Group are musculo-skeletal disorders including vibration, noise induced hearing loss and exposure to hazardous substances.
- Collate and share guideline information on priority health issues – In most cases the MCA will not be developing guidelines to address health issues, as there is no shortage of information and guidance already available on the public record. What is needed is to identify those guidelines which best meet the practical needs of mining operations
- Identify and promote appropriate performance measures for priority health risks - Priority will be given to working towards a suite of performance measures (lead and lag) to report on health issues and trends. Performance measures are also receiving attention from the Health and Safety Taskforce of the International Council on Mining and Metals (ICMM) and the MCA will ensure that its activities are aligned with those of the ICMM's work program on health.

The focus of the MCA on health is very much a work in progress with the clear objective of:

- Identifying the priority health issues for the minerals industry
- Ensuring health is given adequate attention in company risk assessments
- Identifying and promoting practical guidance information for key health priorities
- Developing a suite of key health performance measures/ indicators as a basis for monitoring and reporting.

The overall objective of this work is to assist the industry to manage occupational health issues effectively and be able to report on trends as we currently do for fatalities and injuries in our industry. Until we have the ability to monitor our performance across the industry we will not in a position to say that we as an industry are addressing the occupational health of our workers.

Gaining that Support

John Ninness, Department of Natural Resources & Mines

Introduction

In the last two decades we have witnessed increased pressure on managers and leaders in organisations throughout Australia. The eighties brought about rapid technological changes. In the nineties we saw radical changes that were aimed at improving organisational efficiency. *Downsizing, rightsizing, re-grouping, rationalisation, total quality management and business process re-engineering* were the buzzwords. In many instances these processes failed with significant consequences for the organisations. Senior executives often moved on, while the organisation's long term managers and leaders were asked to pick up the pieces with a leaner workforce and increased output expectations. While the pre-nineties view of management has almost disappeared from our memories over the last two to three years, we are recognising that the role of managers and leaders within organisations is continuing to evolve.

In many organisations managers and leaders are not only expected to perform their traditional functions of supervising, organising, directing and controlling, they are also required to develop a great breadth of knowledge across a variety of complex business disciplines. With rapid changes affecting managers and leaders coupled with increased expectations from the organisation's stakeholders, it starts to become clear that it is often difficult for occupational health and safety to realise its' true importance as a critical element of an organisation's well-being and success.

Influential Factors

Extensive research has been conducted over the years in leadership (Bass, 1990; Hersey & Blanchard, 1988; Senge 1990; Senge et al, 1994; Wheatley, 1994). Many views now surround the psychological makeup of leaders and managers. Recognising that several influential factors impact on a leader/manager's safety decision-making process and overall attitude toward safety can be important to understanding their preferred platform for safety management. These factors may include stakeholder expectations, knowledge of contemporary safety practice along with underlying influences from cultural, psychological, social and environmental issues.

Perceptive occupational health and safety practitioners appreciate that these factors may influence a manager's interpretation of their role in the safety management process.

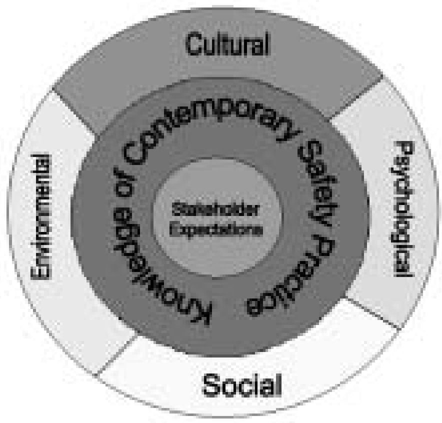


Diagram 1: Factors Influencing Safety Leadership.

In attempting to gain an understanding of each of these issues affecting management attitudes & behaviours, the safety practitioner can begin to comprehend the manager's rationale for decision-making regarding safety. Failure of the safety practitioner to acknowledge the impact of one of these issues upon behaviours may result in preconceived judgments of their manager or leader and subsequently impact the effectiveness of their "influencing" capabilities.

Consider this extreme example of a senior manager. *William moved to Australia ten years ago from a third world country where he had worked in operational roles for ten years. He is a hard worker, a man of technical excellence. He has worked in a number of supervisory positions in Australia and was recently promoted to a leadership role based on his technical excellence and hard work. He is now ultimately responsible for the safety of an entire department. A safety practitioner reports to him. The selection criteria for his position did not reflect safety performance. He has never been held accountable for safety performance before and in his former country "industrial safety" is not recognised. What preconceived views might William have?*

The manager/leader's **perception of their role with respect to safety** will be also influenced by the other factors highlighted in diagram one. Experience shows us that, in many senior management roles in the workplace, decisions and implementation strategies are often based on an individual's subjective interpretation and assessment of the requirements of the role. While their interpretation may be largely influenced by stakeholder expectations, once again, cultural, psychological, social and environmental issues all may indirectly contribute to an individual's perception of their role.

To assist in ensuring role objectivity, many leading organisations now recognise the importance of incorporating safety accountability into position descriptions, job instructions and establishing key performance indicators for individual or corporate safety performance. These processes have largely proven successful in reduction of Lost Time Injury Frequency Rates (albeit that some have been deceptively doctored to ensure that a projected result is obtained).

In considering all these issues, safety practitioners must recognise that managers and leaders view the tasks and the role of the safety practitioner through the *"rose coloured glasses"* of their life experiences. If practitioners can recognise and focus on the positive attributes of our leaders occupational health and safety experiences, we can establish a basis from which to develop our platform for improved safety performance. If we don't or won't recognise our manager's views on occupational health and safety we are trying to build our platform on a base, which may be unstable.

PRINCIPLE ONE

We should find out where our Manager/Leader is coming from and use this as the starting point for influencing safety culture.

PRACTICAL TIPS

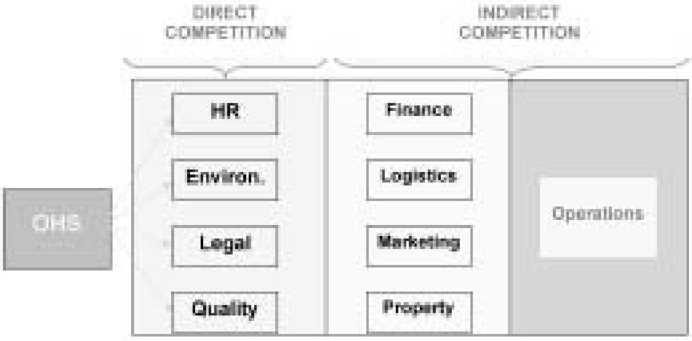
Make an appointment with your manager and ask them some open-ended positive questions like:

- **What do you consider important for me to focus on?**
- **Do you have any ideas on areas that you think I could improve?**
- **We had X accidents over the last three months, I am concerned that this is a reflection on me as a safety practitioner. What do you think I should do to help eliminate these accidents?**
- **From your past experiences, can you highlight to me any best practice approaches to health & safety that I could be using?**

Market Share

While it is recognised that pro-active occupational health and safety should form one of the cornerstones used by management/leaders to build a successful organisation, practitioners must also recognise that there are other critical factors related to the creation of a successful organisation. Many of these functions compete for management attention.

The occupational health and safety practitioner must distinguish that they are competing for management commitment and availability in the same way that organisations compete for market share but on a smaller scale. The occupational health and safety function may directly compete for management attention and, in some respects management commitment, with departmental groups including human resources, environment, legal and quality. In many organisations we see these functions (often labelled as cost centres) are grouped together. Grouping may occur, and a functional head such as a human resources manager or a corporate services manager may be appointed to oversee these activities. The aggregation of these functions may result in decreased management attention on occupational health and safety as information filtering to senior management occurs through a biased departmental head. Ideally, direct reporting relationship to senior management should be established for the occupational health and safety practitioner to minimise information filtering and ensure correct decisions relating to safety can be made rapidly.



The occupational health and safety function may also indirectly compete with finance, logistics, marketing, property and operations. While it is anticipated that management attention is focussed on profitability and operability of the organisation, the operational aspects of their role may consume management such that support functions do not receive due attention.

Practitioners must recognise that marketing of their function is important to gaining support and commitment. Further, they should regularly become marketers of their function and comprehend that such marketing must be carried out internally (management & stakeholders) as well as externally to the workforce. To achieve this, a strategy and plan should be considered to *target* your market.

Consider these aspects of the process:

- You need to understand what your situation is now. ie. Your capabilities and external factors that impact on your function
- Develop your objective i.e. "focus management/leadership function on OHS"
- Establish strategy to meet your objective. Identify whom you want to target and how you will position yourself to meet these targets. You might consider your manager as well as your manager's manager
- Develop an implementation plan
- Evaluate and control.

As discussed in the principle one, practitioners need to understand their manager/leader such that they develop an effective strategy to promote the function to him/her. Understanding that, like people in any market, different managers have different ***buy in*** patterns. Consider a technocratic leader. Practitioners must aim to market towards their technocratic tendencies eg. Discuss the ways in which technology and occupational health and safety may integrate. Table One details a number of different personality traits. Practitioners must consider how they market their services to managers/leadership dependant on their style.

Table 1: Examples of Types

Bill Smith	Fred Nurk	Cathy Jones	Graham Collins
Critical Picky Serious Orderly Exacting Persistent	Pushy Tough Dominating Efficient Decisive Practical	Supportive Respectful Dependable Agreeable Conferring Pliable	Enthusiastic Egotistical Ambitious Excitable Dramatic Undisciplined

(Adapted from Kotlar, P*, Marketing Management – Millenium Edition p p213)*

Consider how you might market occupational health and safety to these types of leaders such that you could gain increased commitment?

PRINCIPLE TWO

We must consider the need to *effectively & continually market* the occupational health and safety function to our management/leadership.

PRACTICAL TIPS

- **Consider writing down five to ten words that describe your manager. Now write down ten ways in which you might market your services to appeal to their personal traits**
- **Read a book about marketing or enrol in a course to find out how the experts do it**
- **Develop and implement a marketing plan for marketing occupational health and safety to your leader/manager and his/her superiors.**

Multi-directional Leadership

Henry Ford once said, *"You can't build a reputation on what you are going to do"*. Planning the activities of the occupational health and safety function are essential to on-going program's success but demonstrable commitment to the cause will assist you to gain the respect and status that ensures your capacity to influence managers and leaders. In many respects the occupational health and safety practitioner must exhibit leadership qualities not unlike that of a highly effective CEO.

Sarros and Butchatsky (1996 p. 283) highlight that there is an increasing emphasis or prevalence among successful CEO's to assume the role of a virtual leader. This model of leadership involves working with management and employees by developing other leaders within the organisation, modelling behaviour and distributing power to make decisions and be held accountable for outcomes to all workers. Ideally, these traits are also desirable for effective occupational health and safety management. Sarros and Butchatsky itemised the key features of virtual leaders:

- They lead from within instead of out in front
- They promote responsibility among their followers
- They make leadership a shared activity not just the prerogative of an elite few
- They guide and nurture, not command
- They are not concerned with power
- They earn respect because of what they do, not what they say.
- They communicate often and clearly
- They monitor the messages they send out
- They work with people at all stages of implementing new programs and ideas
- They are committed to instilling some sense of belongingness in workers
- They achieve credibility through honesty, competence, forward looking behaviour and intelligence
- They delegate often
- They are visible and accessible
- They do not interfere but know what's happening
- They listen well and with empathy
- They captain and coach, guide and counsel as well as direct and control.

Leadership capacity, although often overlooked, can be a key element of the occupational health and safety practitioner's repertoire of personal attributes. Not only must the individual lead the organisation to develop safety as a key aspect of the organisation's culture, he or she must also lead the manager's and leaders of the organisation to developing a proactive approach to safety management.

Underpinning occupational health and safety leadership, direction and vision for the future must be created in the organisation. If there is no direction or vision for occupational health and safety, there may be many misdirected efforts by well-intentioned individuals that in due course result in disillusionment when the vision is eventually established. Ultimately, energies are wasted and frustration and disenchantment become written into the organisation's culture.

Roughton (2002) p53 uses the analogy of an airline pilot taking off without a written flight plan or a business person going on a trip without an itinerary. In the same way, vision and direction for the occupational health and safety must be developed from the organisation's leadership. Occupational health and safety practitioners must seek to align themselves with the organisations vision and contribute to its achievement through effective plans and demonstrable actions. Where no vision for occupational health and safety exists, the practitioner must aim to influence management and leadership to create a vision for the future. To use the old adage "If we don't aim for anything, we will surely hit it " is appropriate.

PRINCIPLE THREE

Demonstrate your capacity for leadership through your on-going actions that align with the organisation's direction and vision for the future.

PRACTICAL TIPS

- **How do you demonstrate leadership in occupational health & safety to your organisation? Ask a confidante to assess you against Sarros and Butchatsky's leadership model**
- **What have you implemented that demonstrates your commitment to organisational vision**
- **Explore the organisation's vision. How does occupational health and safety align with this vision?**

Summary

One of the most fulfilling and often most frustrating issues facing the occupational health and safety practitioner is their relationship with managers and leaders. Availability of quality time with management will no doubt continue to be pressured by operational responsibilities that are essential to survival of the organisation. Practitioners must identify alternate strategies to ultimately improve relationships and, influence leaders/managers to focus due attention on establishing a vision for an incident free working environment.

Not only must the occupational health and safety practitioner be competent in light of the professional requirements, he/she must also be skilled at objectively assessing their manager's viewpoint, strategically marketing the occupational health and safety function and demonstrating leadership traits that are in parallel with highly effective leaders.

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Assessing Risk Assessments at Mount Isa Mines

Maryann Wipaki, Health & Safety Department, Mount Isa Mines

Introduction

Through statutory change and increasing improvement in Occupational Health & Safety systems, the Health & Safety department of Mount Isa Mines found it necessary to review the Risk Management standard. The Risk Management standard aims to provide a guideline in the identification of workplace hazards, assessment of the risks posed by them, introduction of the most appropriate control and monitoring the effectiveness of this control. Whilst this is not a new process and was aligned specifically to AS-4360 Risk Management, it prompted the development of tools to assist workers in performing formal risk assessments of their daily routine work, two of these tools were Task Analysis and Effectiveness of Controls. This paper aims to briefly describe the risk management process using task analysis and in particular analysing the effectiveness of the controls recommended.

The Evolution of Task Analysis

Task analysis is the process of systematically listing the steps within a workers task, with the intent of having enough detail to easily identify the hazards in each step. Within the Copper Mining Stream we adopted a system developed by the Industrial Foundation for Accident Prevention (IFAP) to improve the quality of Incident Investigations, monitor the development of Standard Work Instructions (SWI's) and improve the quality of Workplace Inspections. Each of these three components are controlled by a small working team. The investigation and inspection components are quite rigid documented processes and relatively easy to implement and drive change, however applying a 'scientific' approach to when, where and why an SWI should be developed proved more challenging.

The SWI Team developed a scorecard system for Copper Mining Superintendents. This system allowed Superintendents to list all the tasks in their respective areas and prioritise the order of review using a simple risk calculator which considers consequence, likelihood and frequency of task. Once the scorecards were developed the Task Analysis was completed by the workers.

Following the standard risk assessment principles, the worksheets were changed to provide a more systematic and simplified approach of working through each hazard scenario. The participant identifies the hazard scenario, existing controls, risk score, additional controls and residual risk across one line on the same page. The Task Analysis (and risk assessment) process was proceeding well, however through the review facility provided by the SWI Team, it was evident that the level of understanding with risk assessments varied, in addition there was conjecture regarding what determined the requirement for an SWI. Whilst there was agreement that SWI's should be developed for critical tasks - what score or process determined the task critical?

Risk Assessment Quality Check

Focus was changed to developing a rigid process to review the quality of the risk assessment in order to determine whether all controls were considered before relying on an SWI to control the task. The review needed to capture the entire risk assessment process.

The document concentrated on key areas:

- Determining whether the hazard scenario's were well defined
- Confirming the risk scores were credible
- Determining whether the additional controls were adequate
- Confirming the residual risk score
- Determining whether the task was critical.

Hazard Scenario

Stringent criteria was applied to the hazard scenario in particular each scenario had to include a target (person/equipment/environment etc) a consequence (injury/damage etc) and a hazard source. This achieves the benefit of allowing the person reviewing the risk assessment to understand the hazard and confirm/re-calculate a realistic risk score, whether this be through the quality check process or reviewing the risk assessment at a later date for currency.

Risk Score

The method we have used to calculate the risk score considers consequence and likelihood. Consequence is measured using a numerical indicator on the most credible outcome and likelihood is measured using an alpha indicator considering probability and exposure ie how often the target may come in contact with the hazard source resulting in the consequence described. A 5x5 risk matrix is used to obtain a value of the consequence and likelihood.

Table 1: 5x5 Risk Matrix.

Mount Isa Mines
Risk Analysis Matrix

A	11	16	20	23	25
B	7	12	17	21	24
C	4	8	13	18	22
D	2	5	9	14	19
E	1	3	6	10	15
	1	2	3	4	5

Consequence		Likelihood	
5	Catastrophe	A	Almost Certain
4	Major	B	Likely
3	Moderate	C	Occasional
2	Minor	D	Unlikely
1	Insignificant	E	Rare

Extreme	**STOP** work and Contact Supervisor
High	**Immediate** Action Required
Moderate	**Action** Required
Low	**Monitor**

Control	Reduces	Action
Elimination	Consequence/Likelihood	Remove, redesign the process or plant so the hazard does not exist
Substitution	Consequence/Likelihood	Hazard substituted with something of a lesser risk eg red rating chemical with amber rating chemical
Engineering/Isolation	Consequence/Likelihood	Hazard controlled through isolation using an engineering measure eg machine guarding
Administration/Training	Likelihood	Hazard controlled by influencing people eg SWI's, procedures, job rotation and signage
Personal Protective Equipment	Likelihood	Hazard controlled by the use of personal protective equipment eg hearing protection in noisy areas
Behaviour Management	Likelihood	Hazard controlled by individuals attitudes, personality, beliefs, actions, assumptions, reactions, skills, knowledge, abilities eg driving within the speed limit

Additional Controls

The area that caused the most consideration was the level of additional control. Controls reduce risk of an incident by lowering the consequence or the likelihood or both, in many cases a combination of controls will be used. When assigning controls to a hazard emphasis should be on systematically working through each level of the hierarchy of controls from the most effective control to the least effective control. Once again this was not a new concept, however we focused on measuring the effectiveness of the control recommended ie does the control reduce the consequence, the likelihood, or both?

A simple scoring system in line with the 5x5 risk matrix (1 – 25 numerical score) was applied to the additional controls. To meet the intent of the review, each type of control could only be scored once:

Elimination	25 points
Substitution	20 points
Engineering/Isolation	15 points
Admin/Training	5 points
PPE	2.5 points
Behaviour Mgt	1.5 points

The additional control scores are totalled and if they did not reach the risk score confirmed previously then they were not acceptable to control the level of risk.

Residual Risk Score

Fundamentally if the additional controls 'did not' fall into the control groups of Engineering/Isolation, Substitution or Elimination, then the consequence remained the same. The additional controls are considered when calculating the residual risk score using the risk score method described earlier.

Critical Task

We firstly determined that generally a high or extreme residual risk score would require an SWI, however after reviewing the residual risk scores often risks which fell into the moderate range relied solely on administration controls – these could well be considered as critical tasks. This prompted the introduction of a number of checks and balances against the additional controls when they did not reach the desired score:

- Were the additional controls Administration/Training, PPE and Behaviour Management?
- Was there scope to introduce higher or additional controls?

By answering yes to the first question and no to the second question this would warrant consideration of a critical task and development of an SWI.

Guidance on the Use of Administration Controls

The requirements of procedures, SWI's and training were layed across the top of our 5x5 risk matrix and are based on residual risk scores. In addition definitions exist for the different levels of training.

We recommended that SWI's were not developed in isolation – that they should form part of procedures and structured training programs.

11 Procedure Formal Training Stringent Testing Level 2	16 Procedure Formal Training Stringent Testing Level 2	20 Procedure SWI Formal Training Stringent Testing Level 1	23 Procedure SWI Formal Training Stringent Testing Level 1	25 Procedure SWI Formal Training Stringent Testing Level 1
7 Procedure Self directed learning with general assessment Level 3	12 Procedure Formal Training Stringent Testing Level 2	17 Procedure Formal Training Stringent Testing Level 2	21 Procedure SWI Formal Training Stringent Testing Level 1	24 Procedure SWI Formal Training Stringent Testing Level 1
4 Provision of information general assessment Level 4	8 Procedure Self directed learning with general assessment Level 3	13 Procedure Formal Training Stringent Testing Level 2	18 Procedure SWI Formal Training Stringent Testing Level 1	22 Procedure SWI Formal Training Stringent Testing Level 1
2 Provision of information no assessment Level 5	5 Provision of information general assessment Level 4	9 Procedure Self directed learning with general assessment Level 3	14 Procedure Formal Training Stringent Testing Level 2	19 Procedure SWI Formal Training Stringent Testing Level 1
1 Provision of information no assessment Level 5	3 Provision of information general assessment Level 4	6 Procedure Self directed learning with general assessment Level 3	10 Procedure Formal Training Stringent Testing Level 2	15 Procedure Formal Training Stringent Testing Level 2

Summary

This process is being used by the workforce through the facilitation and review of risk assessments and is fundamentally accepted. Discussion continues with regard to the use of some engineering controls for example engineering controls that rely on procedures to enforce - isolation and lockout, barricading etc would be scored in the process as an administration control given that to be effective, it relies solely on the person to implement.

We have encouraged consideration to defences in layers, particularly when relying on administration controls you may have many things (SWI, procedures, pre-starts, inspections etc) that would need to fail before the target came in contract with the hazard source.

Whilst we do not suggest that we have answered all areas of conducting a risk assessment as it still relies on the participants perception of the risk when scoring, we believe that we have implemented a sound tool to review the quality of the risk assessment and effectiveness of the control implemented.

Safety Applications for GPS Systems in the Mining Industry

Chris Seymour, Automated Positioning Systems Pty Ltd

Introduction

The Global Positioning System (GPS) has been available for civilian use for more than 20 years now. It has found many navigation, surveying, tracking and recreational uses. The technology is mature and GPS hardware has become reliable and widely available from diverse suppliers.

How It Works

The US NAVSTAR system has about 28 GPS satellites in orbit. The number varies slightly as old ones are retired and new ones launched. Each satellite carries a highly accurate Caesium atomic clock. The satellites put out a coded time and position signal.

A ground receiver with a similar atomic clock can compute the travel time of the signal and hence the range to the satellite.

Theoretically sighting three satellites should be sufficient to determine the position of any point on the globe by trilateration.

However it is impractical to include an atomic clock of sufficient precision with the ground receivers. This problem can be overcome by sighting four satellites. Precise time can then be calculated as the fourth unknown, along with the position co-ordinates.

Accuracy

In theory it should be possible to use the coded signal to determine position to within 300 mm. In practice variations in the travel time of the signal due to atmospheric conditions and other factors limit the accuracy of stand alone GPS units to 10 to 25 metres.

It is possible to improve on this level of accuracy by utilising a reference station, whose position is precisely known, to broadcast correction signals. The roving GPS unit can then use this signal to correct its calculated position. This arrangement is known as Differential or DGPS.

There are a number of commercial and free to air correction services in use. The Australian Maritime Safety Authority (AMSA), for example, covers about 60% of the Australian coast with DGPS signals.

AMSA specifies the accuracy of their network as better than 10 metres, 95% of the time. Accuracy falls off with distance from the reference station, but our experience indicates that sub metre accuracy is possible within a 50 kilometres radius.

Still higher precision it is possible by moving to a method called Real Time Kinematic or RTK.

RTK systems measure the carrier phase of the satellite signal as well as the code phase. In addition dual frequency receivers can measure two separate frequency signals from each satellite, which enables them to correct for a number of different errors.

Typically RTK reference stations need to be closer to the roving GPS receivers. A minesite will generally need to have its own reference station. All of this adds to the cost and complexity of RTK systems. RTK receivers are anyway more expensive than stand alone or DGPS receivers.

In theory RTK systems could be capable of millimetre accuracy. In practice, current best technology achieves accuracies of about 25millimetres. However this is still good enough to be of interest for surveying and machine control applications.

Surveying

Most mines now use RTK GPS systems for surveying. GPS considerably speeds up the surveying process and reduces the time surveyors are in the field often in vulnerable locations. For example, because the GPS system gives an absolute position, the tedious process of establishing field control points is entirely eliminated.

Truck Fleet Management

Many mines are fitting GPS systems to their trucks for fleet management purposes. Trucks can be assigned to different loading machines in real time to improve overall efficiency. A side safety benefit is that the central control station knows at all times the whereabouts of each truck in the fleet. Stand alone GPS is generally adequate for this task.

High Precision Machine Control

Many mines have started to fit high precision guidance systems to their mining equipment. The systems are accurate enough to eliminate the need for survey design pegs in the field.

Besides greatly increasing efficiency, this eliminates the need to have people on the ground outside vehicles, where they are most vulnerable to accidents.

Dozers for example can complete earthworks, such as dams or drainage channels with no field pegging. Not only do the surveyors not have to put the pegs in, but the operators do not have to climb out of their cabs to look at them. Moreover the machines record the positions that they have worked and so build a gridfile of the completed job. This can be turned into an "as-built" drawing – all without ever having a surveyor in the field.

A further safety benefit of the GPS system was recently revealed when a dozer was involved in a rollover accident. The sequence of events leading to the accident could be thoroughly reviewed because the GPS system had recorded the position of the dozer every few seconds.

Blast hole drills can be set up to complete the blast pattern without the need for surveyors, or the drillers to mark out each hole – again eliminating the need for people to work in the open.

On shovels and excavators, GPS systems can be set up to indicate the exact location of the bucket in three dimensions relative to the boundaries of the orebody or coal seam. In situations where the ore is not readily distinguishable from waste, this can save considerable field time for geologists and surveyors in marking out the ore body limits. Similarly in coal, the ability to selectively mine bands of different qualities is greatly enhanced, again without the need for people on the ground.

Figure 1: GPS systems such as this APS installation on an excavator at Century Mine can largely eliminate the need for people on the ground.

Hazard Avoidance

GPS systems can be set up to warn the operator of site hazards. For example a hazard warning system has been set up as a trial on a dozer at the Gladstone Port Authority. The dozer is working on a coal stockpile as shown in the photograph in figure 2.

Coal from this stockpile is reclaimed through feeders under the stockpile. The dozers push the coal into the feeders. Sometimes the coal bridges, creating a void above the feeder. If the dozer ventures onto the void it will collapse and potentially cause a very serious accident. The GPS system warns the operator when he is getting close to the feeder position. This is often hard to see when the stockpile is full of coal.

Figure 2: Dozer at Gladstone Port Authority coal stockpile fitted with GPS warning device from APS.

The dozer is fitted with a cab computer which shows the dozer in its true position on a map of the site. It is also fitted with a light bar. More lights progressively come on as the dozer approaches the hopper position. At one metre a warning sounds.

For the accuracy required for this system DGPS is quite adequate – offering substantial savings over an RTK system.

Currently the system is set to warn of the approach to the hopper position in two dimensions. However the GPS system is reading the position of the dozer in three dimensions, and it would be quite possible to allow for the angle of repose of the coal.

It is also possible to set up the dozer so that it automatically broadcasts an assistance required signal at the operators command or if it is tilted beyond a preset angle. The signal from the machine can include its position, making it easy to find.

A similar situation of hazardous openings is encountered in many open pits where the deposit has been previously mined by underground methods. The situation at a gold mine in Western Australia is shown in figure 3. The numerous voids present a severe hazard to mining equipment and vehicles. Most dangerous are the unseen workings just below the current bench level. If the positions of these workings are known, then a GPS system is one way that individual items of equipment could be kept away from the hazard zones.

Figure 3: Voids from old workings at a West Australian Gold Mine.

Collision Avoidance

Another possible use of GPS to enhance safety is in collision avoidance. If all mobile vehicles are fitted with GPS and telemetry systems, they can continuously report their position to a central control base. Software at the base can then analyse the data and warn when two vehicles are on a collision course, as is done with civilian air flights in crowded air corridors.

Such a system is possible, but requires high bandwidth telemetry systems to poll all rovers on a rapid basis. This kind of arrangement would be especially beneficial in areas where light vehicles and high speed long distance ore haulers are mixed.

Reliability

The GPS system has been in place for a long period of time and has come to be relied on for many commercial purposes. On May 1st 2000, President Clinton removed the intentional degradation of GPS signals known as Selective Availability. A repeated theme of Presidential decrees on GPS has been to "encourage acceptance and integration of GPS into peaceful civil, commercial and scientific applications worldwide; and to encourage private sector investment in and use of U.S. GPS technologies and services." It is unlikely that the US will re-impose Selective Availability or otherwise disrupt the GPS system. The use of reference stations in either DGPS or RTK effectively negates the effects of Selective Availability.

Number of Satellites

There is one problem in using GPS in mine site situations, which has become increasingly obvious over the last 12 months. As explained earlier, four satellites are necessary in order to obtain a fix in three dimensions. For high precision RTK operation five satellites are necessary. With the current constellation of 28 GPS satellites, there are rare occasions when only three are visible and almost daily occurrences of only four visible GPS satellites. This applies to a receiver on a flat plain which has an unobstructed view of the full sky.. In a pit where part of the sky is obscured by the pit walls, satellite availability may prevent 24 hour continuous coverage.

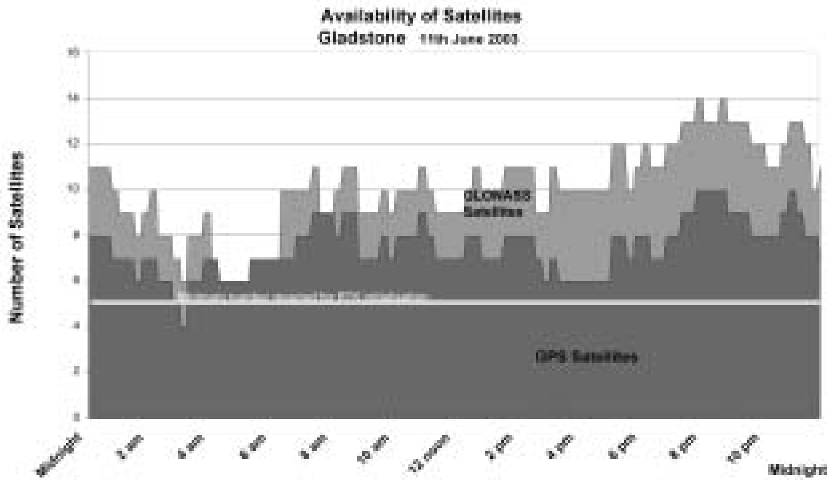
There are four potential means of overcoming this shortcoming:

1. Planning. It is quite easy to predict the periods of low satellite availability or when particular areas in the pit will be blocked from sufficient satellites. Using this information, activities can be scheduled around the down times. This is quite practical for surveying applications, less satisfactory for machine guidance and not at all acceptable for safety applications.

2. Other Satellites. As well as the US NAVSTAR system, the Russians have a GPS navigation system too – known as GLONASS. GLONASS was originally launched in the early 1980s for the military forces of the USSR. It has had mixed fortunes over the years, but the Russians are now actively funding it. GLONASS currently has only nine active satellites, but more are being launched and the system is planned to reach its full constellation of 24 satellites in 2005. Some GPS receivers can access both sets of satellites, giving a total constellation of thirty seven. Dual access, while not guaranteeing 100% availability goes a long way towards it. The chart in figure 4 shows how the GLONASS satellites fill in the gaps left by the NAVSTAR satellites.

The European Space Agency is also planning a GPS network – to be known as Galileo. The Galileo system will have a similar number of satellites to Navstar and is planned to be operational in 2008. It is not yet known whether the Europeans will levy a charge for the use of their system. Receivers capable of seeing the 72 satellites from all three systems would be continuously available for high precision positioning in all but the deepest and most steep sided of pits.

Figure 3: Availability of satellites over a 24 hour period.



3. Inertial. In theory inertial guidance packages should be capable of retaining positions between sighting of GPS satellites. Inertial packages have been well proven in highwall mining applications. In these applications they have been able to maintain design pillars between entries to accuracies of a few centimetres over 500 metres. However current systems are too expensive and their ability to hold a position is too limited for application in most surface mining equipment.

4. Pseudolites. A number of groups are working on artificial satellites or "Pseudolites", which would be placed on the pit walls. For various technical reasons, including the swamping of the weak satellite signals by the close pseudolite signal, none are yet commercial. However this technology has great application for the future.

Conclusion

GPS survey and machine guidance applications are finding increasing acceptance in the mining industry. Widespread adoption of this technology has important safety benefits as a by product. In addition there are a number of applications where GPS systems may be fitted for primary safety purposes. Lack of satellites is the major problem to be overcome, but there are a number of possible solutions and more will be available in the future.

Manual Handling - Reducing Injuries

Peter Cameron, Xstrata Copper Australia

Introduction

Manual handling describes an activity requiring the use of force exerted by a person to lift, lower, push, pull, carry or otherwise move, hold or restrain any person, animal or thing. Tasks involved can vary from keyboard use to carrying a box to handling large pieces of equipment.

Injuries due to poor manual handling techniques are the most common and most costly category of work-related injuries, accounting for over 40% of injuries within Xstrata Copper Australia Mount Isa operations. Many employees suffer painful injuries while performing manual handling tasks. The most common injuries due to manual handling are back injuries, sprains and strains and Occupational Overuse Syndrome (OOS). The costs of these manual-handling injuries, average $11 000 per Disabling Injury[1], are enormous in human, financial and social terms to the employee, employer and the Mount Isa community.

In order for preventative occupational health and safety measures to be successfully implemented and maintained, policies and activities, such as an effective Manual Handling audit tool, need to be integrated into existing operational safety management systems and not simply added as an appendix or afterthought. The adoption and adaptation of the Queensland Manual Tasks Advisory Standard 2000 have achieved this.

There is a strong link between Occupational Health and Safety, productivity and employee / employer relations. Improved OHS practices have key benefits for employers and employees. These include an improved industrial relations climate due to greater consultation, a safer and healthier working environment for employees and substantial savings in workers' compensation and rehabilitation costs (Xstrata Copper Australia is a self-insurer). Organisational management systems, which are OHS inclusive, provide a framework for change and support long term improvements in work practices, in turn providing a safe work environment and safe systems of work.

Employees who perform manual handling tasks are familiar with the risks and difficulties they face. The people actually doing the jobs will have ideas about safer and more efficient ways to do the task. Tapping into the employees' knowledge is more likely to achieve an acceptable and lasting solution. It is imperative employees and/or their representative should be consulted, as was the case at Mount Isa, through the whole *process of risk identification, assessment and control.*

Program

The Manual Handling program was first introduced to the operation in July 2002 under the guidance of Maryann Wipaki (Safety Adviser Xstrata Copper Australia Mount Isa Operations). Transport operations – Mobile Fleet Workshop was identified as a major high-risk area for manual handling injuries, therefore efforts were concentrated in this area in the first instance and later extended to include Supply and Contracts operations on both the surface and underground environments. The following process was followed:

Manual Handling Process

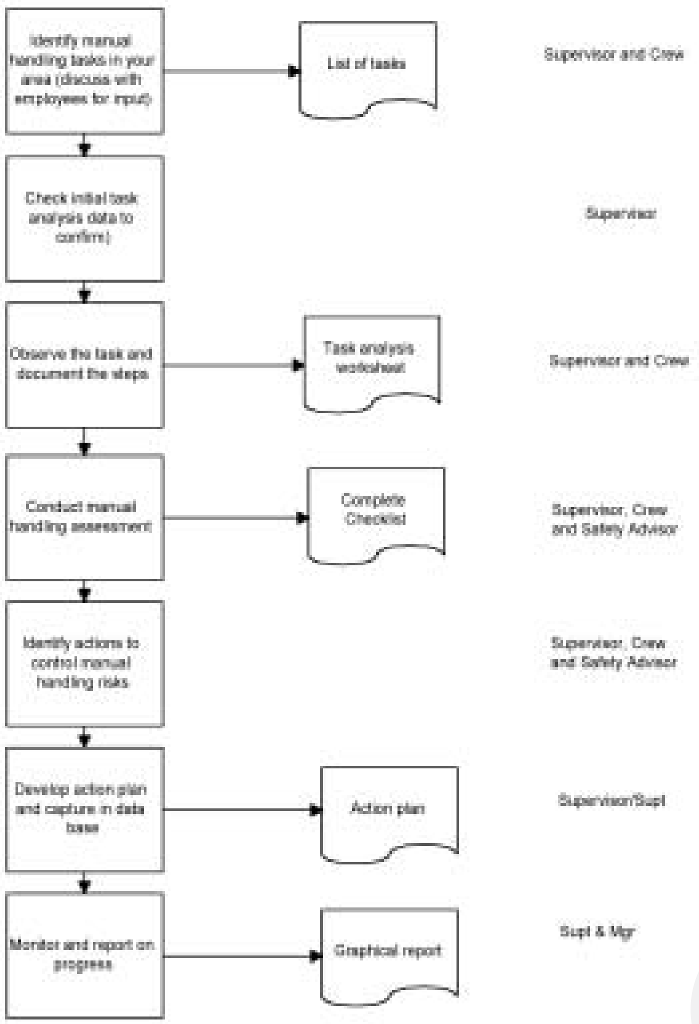
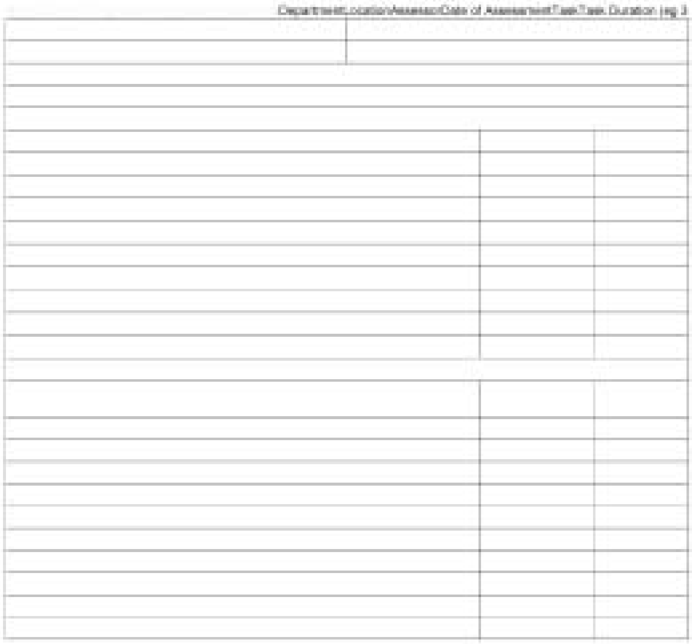


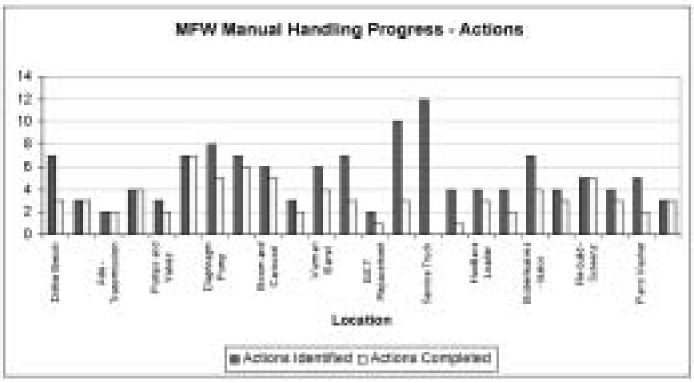
Figure 1: Calculations based on random selection of Mount Isa operations Metallurgical Plants data.

Cover page: Manual Handling Checklist(s)

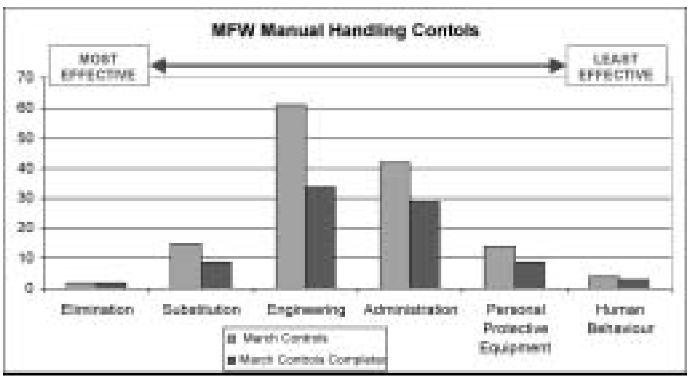


The audit document consists of a series of checklists; subject heading listed in the table above. A series of questions are asked and a point is awarded for a response to a predetermined preferred answer, for each question. If a preferred answer is not given, generally a problem area has been identified, further investigation is needed and appropriate controls implemented to eliminate or reduce the risk. Checklist(s) is available in the Queensland Manual Tasks Advisory Standard 2000.

Monitoring of Program Progression

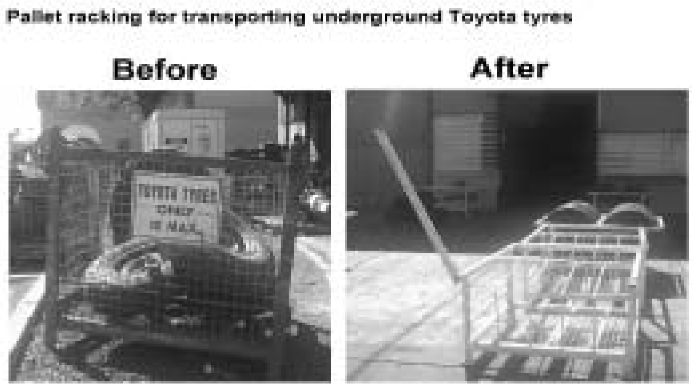


Positive performance indicator used to monitor actions completed versus actions identified.

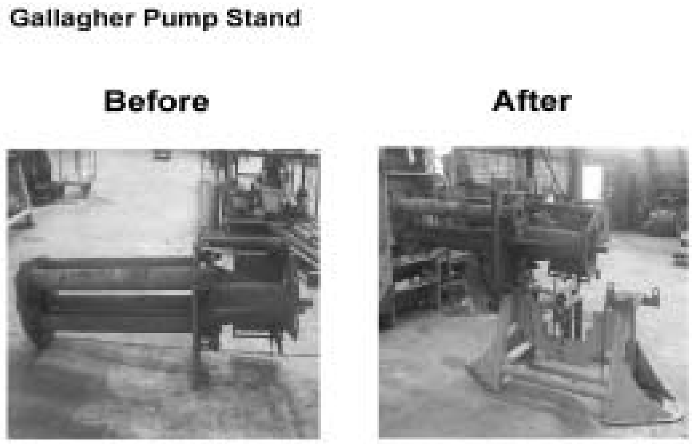


When determining suitable controls for Manual Handling risks, the Hierarchy of Controls is used with empathises on achieving the most effective measure appropriate to the task.

Manual Handling Improvements



High potential risk of back injuries occurring when attempting to lift tyres from the storage cage. Solution: Re-design cage for ease of access (Roll in/Roll Out).



Gallagher pump required repair work performed at ground level creating high potential muscle strain/injury environment. Solution: Design and fabricate purpose built stand to accommodate pump at workable height.

The Future

Continued Evaluation & Review

Continued evaluation and review is necessary in order to:

- Make sure that the changes are adopted correctly
- Be certain that the changes help reduce risk of injury
- Check if changes need further improvement or modifications
- Make sure that the changes are not causing other problems.

Over a given time period the program will be introduced to the remaining sectors of the operation. It is envisaged that future developments will take place in improving design concepts, technology and work practices across the company. It is important that each of the workplaces within the operation take into account these changes as appropriate. The process of evaluation and reassessment and control of manual handling risks is an ongoing process.

Target: "Zero Injuries"

Technology Aimed at Improving Mine Safety

Michael Hood, CRC Mining

Abstract

A range of technologies currently being developed at the University of Queensland in the Division of Mining and Minerals Process Engineering and its related mining research Centres is described. These technologies seek to improve mine safety by: (i) reducing mining hazards, (ii) reducing physical and mental stress whilst operating equipment and, (iii) improving operator training.

In the first category a novel drilling technology is outlined that improves the effectiveness of gas drainage from coal seams. Another technology in this category is reported which improves our understanding of spontaneous coal combustion. In the second category a new sensor and alarm system is detailed which alerts truck drivers when they lose concentration. Two other technologies in this category are presented. One monitors the quality of haul roads and reports to management when the road deteriorates to a point where it needs repair, that is, when the stress to the driver and the truck exceeds a pre-defined limit. The other is an alarm function that alerts a driver when other vehicles and humans are in close proximity to a haul truck – this should help prevent future accidents where trucks unknowingly run over other vehicles. In the third category a new technology is described that uses a virtual reality system for operator training.

Technologies to Reduce Mining Hazards

Improved Gas Drainage from Coal Seams

The majority of coals seams mined in Australia today can be characterised as gassy and relatively impermeable. The quantity of these gases contained in the seams must be reduced to safe levels before underground mining of the coal can take place. The low seam permeability makes this gas reduction operation difficult. In general the most, and often the only, effective way is to drain the seams by drilling holes in regular patterns in the coal. The gas flows into and along these holes and from there into pipes which convey it safely to the surface.

Today in Australia some 300 km of these inseam holes are drilled each year from underground workings across coal blocks that are to be mined. These holes are made using directional drilling techniques at a cost of about $100,000/km, or a total annual drilling cost of about $30 million. The instantaneous drilling speed achieved by these drills is a respectable 2 m/min, but the delays involved in drill set up, drill pipe installation and removal, surveying and steering, reduces the effective drilling rate to about 80 m/shift; equivalent to less than 0.2 m/min. Obviously the drilling cost is related to the effective drilling rate. In other words if the effective rate was increased the cost would fall.

A new drilling approach that has the promise to displace much of this underground drilling is the surface-to-inseam method. The technology that has been most widely applied to date is medium-radius drilling (MRD) which starts with an inclined hole at the surface. This hole is deviated into the plane of the coal seam and then drilled for a long distance, typically 1 km, in the seam. The hole is steered to intercept a vertical well (Figure 1). A pump is installed in this well to lower the water table, thereby reducing the pressure in the seam and allowing the gas to flow. To date only about 10 MRD holes, equivalent to only about 3% of the annual length of holes drilled, have been developed for mine drainage.

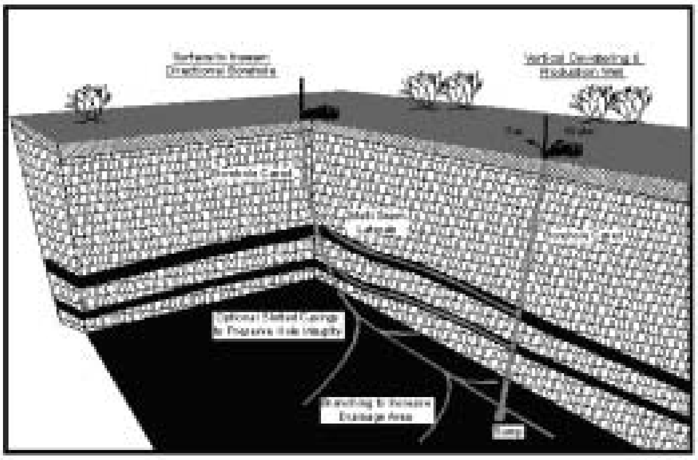


Figure 1: Schematic of medium radius drilling (MRD) operation (from Thomson et al, 2003).

Although the cost per unit length of these MRD holes is comparable to the holes drilled from underground they have advantages over underground drilling that makes the trend towards surface-to-inseam drilling compelling. First, the surface holes can be drilled years in advance of the mining operations, allowing ample time for the gases to drain, eliminating any disruption to mining. Second, the drilling operations are conducted from the safety of the ground surface.

A significant problem with both the underground and the surface-to-inseam drilling is that no additional information about the formation is gathered during the drilling operations. If, for example, sensors were mounted on or behind the drill to monitor changing geological structure (faults, rolls, mylonite zones, dykes, etc) during the drilling operation then this new information could be incorporated to improve the performance of the mining system; this would help justify the drilling costs.

The University of Queensland is the major research partner in the Cooperative Research Centre for Mining Technology and Equipment (CMTE). This Centre has developed a novel, water-powered drilling technique that potentially can substantially improve the performance of both the underground drills and the surface-to-inseam drills. Furthermore, CMTE, with its research collaborators at the University of Sydney and CSIRO, is developing a suite of new geophysical tools that could provide information on the geological formation during the drilling process.

Figure 2 shows this new drill. It is supplied with high pressure water through a flexi-ble hose which runs from the high pressure pump located on the surface over a take-up drum on a surface rig and connects the back of the drilling tool. The water is emitted through a number of nozzles that are aimed at acute angles off the tool axis at both the front and rear ends of the drill. The nozzles on the front are mounted in a swivel and angled in a manner that causes the front end of the tool to rotate, in a manner similar to a garden sprinkler. These are the cutting jets that excavate the hole. More than half the jet power is directed through stationary (non-rotating) nozzles at the rear of the tool. These jets provide the thrust necessary to advance the tool along the hole.

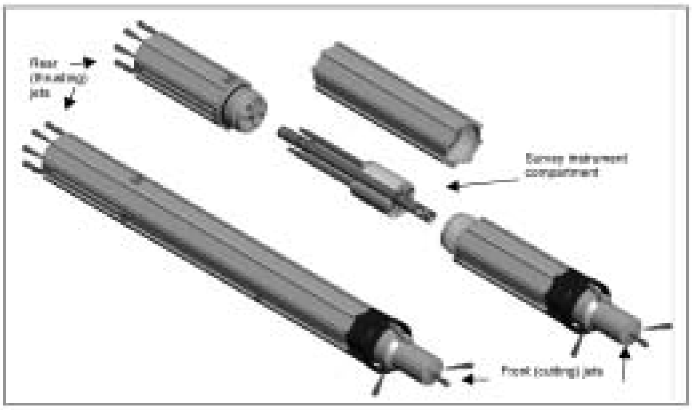


Figure 2: CMTE's water powered drilling tool assembled view (lower figure) and exploded view (upper figure).

Built into the drilling tool is a survey instrument that provides real-time, continuous positional data to the drill crew (Figure 2). Also built into the drilling system is a steering mechanism. Once drilling starts any deviation from a desired trajectory can be monitored using the survey instrument and steering corrections can be made.

For underground drilling applications one of the principle advantages of this water powered drill over conventional directional drills is a much faster effective drilling rate. This is achieved by a combination of a faster instantaneous rate – the research team has routinely recorded instantaneous drilling rates in excess of 5 m/min – and greatly reduced looses during drilling – since the drill string is a continuous hose no time is lost in making up tool joints and, since the drill survey data is continuous, no losses are incurred in making survey measurements. To date these advantages have been demonstrated only by drilling in highwalls because the equipment has yet to be approved for underground use.

For surface-to-inseam applications the potential benefits are even greater. Because the drill is attached to a flexible hose, rather than rigid drill rods, it can be directed around sharp corners. The drilling system that CMTE has developed to take advantage of this is called tight-radius drilling (TRD). The system (Figure 3) works by first drilling a vertical well and reaming out a cavity (1.8 m in diameter) at each seam horizon. These operations are performed using standard conventional drilling methods. An erectable arm is then lowered on rigid drill pipe into the cavity of the first seam to be drilled. The hose is then paid out drill to lower the drill into this arm with the arm in the vertical position. The arm is then raised to a horizontal position and rotated to point in the compass direction where drilling is to take place. The high pressure water is then applied to the drill causing the drill to leave the arm and start drilling in the coal. The survey data is transmitted back to the surface and steering corrections are applied as necessary.

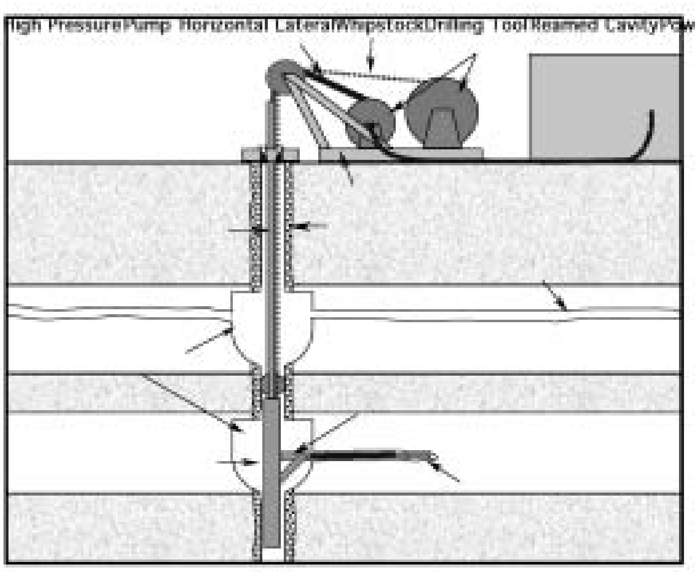


Figure 3: Schematic of tight-radius drilling (TRD) operation.

Thomson et al, (2003) described the advantages of TRD over MRD:

- TRD allows for a single vertical well (conventionally drilled) to service any number of lateral turnouts, including multiple seams. This provides for a very high ratio of metres drilled in coal versus metres drilled in barren ground
- De-watering can be achieved by using a simple rod and plunger style pump located at the bottom of the vertical well. MRD requires the placement of an adjacent vertical well (in addition to the horizontal well) to de-water the seam
- The capital cost of down hole equipment is likely to be significantly less than with MRD systems.

However, the key advantage of TRD technology over MRD is the ability to target multiple coal seams (of variable thickness) from a single central well (working away from the position of maximum geological control).

TRD has been used to drill out coal seams from three vertical wells, one at (what was then) BHP Mitsui Coal's Moura mine, and two at Anglo Coal's Grasstree mine. Gas drainage from these holes has been excellent.

At Moura the peak gas flow was measured at 1 TJ/day (28,000 m^3/day) and, some four years later was still producing about 0.3 TJ/day (10,000 m^3/day). At Grasstree one of the holes was strategically located adjacent to a shaft that was being sunk in order to degas the shaft bottom area to facilitate mine development. This development is now taking place and, pleasingly, only low gas values have been found underground.

Spontaneous Combustion Research – Bulk Coal Self-heating Tests

A 2-metre, adiabatic column (Figure 4) is used in the Division of Mining and Minerals Process Engineering at The University of Queensland to monitor the self-heating of 60 litres of as-received or as-mined coal up to temperatures of 250°C (Beamish et al., 2002, 2003).

This type of testing is able to produce results that closely simulate the conditions that exist in industry. The information obtained from the column is also ideal for teaching the fundamentals of spontaneous combustion in particular the use of gas ratios as indicators of the status of a heating. Results are directly applicable to hazard management of spontaneous combustion during mining, transport, storage and building spoil piles.

Since late 2001, 20 test runs have been completed with a 100% success rate. From these tests it is clear that the column has a number of significant advantages.

These are:

- The test is performed on as-received bulk coal (60 litres or 40-60kg of coal depending on packing density used) up to a maximum temperature of 250°C. This maximum temperature has been progressively established to maintain strict safety standards during testing
- Tests results are available in days, with a full history of the self-heating development of the coal (Figure 5). The longest test run to date has taken 28 days to complete, with the majority of tests taking less than 14 days
- Moisture transfer effects are clearly visible, particularly in the early stages of heating development (Figure 5), whereby there is a significant temperature increase towards the top of the column due to moisture condensation in the coal pile
- "True" off-gas is liberated and monitored from the self-heating process of the coal, including any moisture driven and gaseous feedback reactions leading to "fire-stink"
- Hot spot development and propagation can be quantified (Figure 5)
- Direct impacts of changes in airflow rate, particle size, air temperature and starting coal temperature can be assessed
- Effects of the presence of pyrite and seamgas can be assessed
- Simple coal quality relationships can be determined for any mine that can also be related back to small-scale adiabatic R_{70} testing
- Mine strategies to control self-heating can be assessed, including: ventilation changes, inertisation, and inhibition.

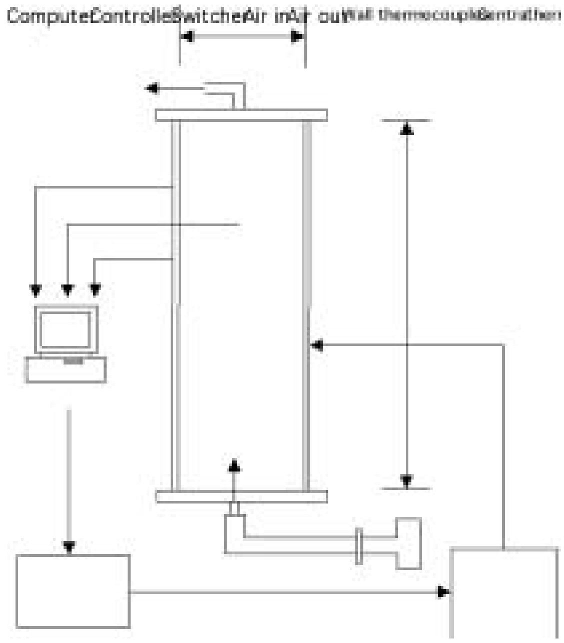


Figure 4: Schematic of UQ 2-metre column self heating apparatus (modified from Arief, 1997).

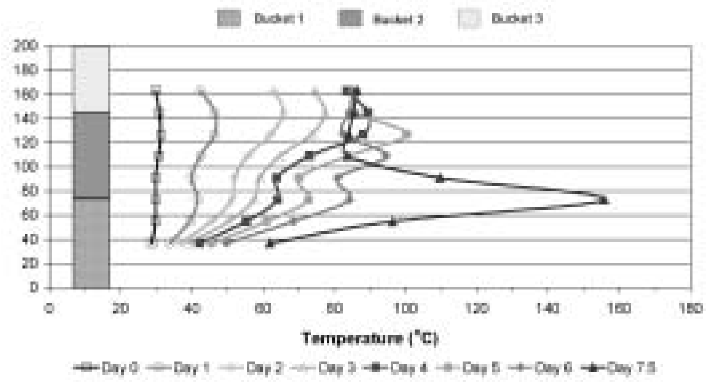


Figure 5: Column temperature profile showing hot spot development.

Technologies to Reduce Physical & Mental Stress

Truck Driver Alert System

"A 290 tonne truck drifts across the centreline of the haul road and hits another truck head-on. A load of overburden is absent-mindedly dumped into the crusher, shutting down the mine for 12 hours. And yet another haul truck drives through a curve in the road, rupturing a pipeline and dumping 322,000 litres of raffinate on the ground. These incidents, and countless others, had three things in common. First, all the operators were well trained and experienced. Secondly, they had excellent safety records. Thirdly, they were all working the back end of the night shift."

(Sirois, W., 2003)

The haul truck alignment monitoring and operator warning system seeks to prevent accidents caused by driver fatigue. It warns the driver when the haul truck deviates from a specified operating corridor, and it also alerts other trucks of the potential hazard. The work has been performed by CMTE's research partners at The University of Sydney.

The system (Figure 6) uses a scanning laser to detect existing guideposts by measuring-ing the time of flight of the laser light pulses. The pulsed laser beam is deflected by an internal rotating mirror so that a fan-shaped scan is made of the surrounding area. The system then calculates the distance of the haul truck with respect to a virtual wall formed by the guideposts in real time using an embedded processor (Figure 7). When the truck veers too far off course, the system issues a series of staged warning signals to alert the operator including both visual and audible alarms. Special infrastructure in the form of three guideposts close together can also trigger the audible alarm to signify strategic locations such as intersections.

Figure 6: Haul truck operating with the system at Comalco's Weipa mine.

The system is integrated with other sensors, including GPS, to provide speed and location of the vehicle. Warning lights are placed on the roof of the truck and these flash when the alarm is activated to warn on-coming drivers of a truck veering off course. This is an improved safety benefit for all other trucks in the fleet and gives the other drivers an opportunity to take evasive action.

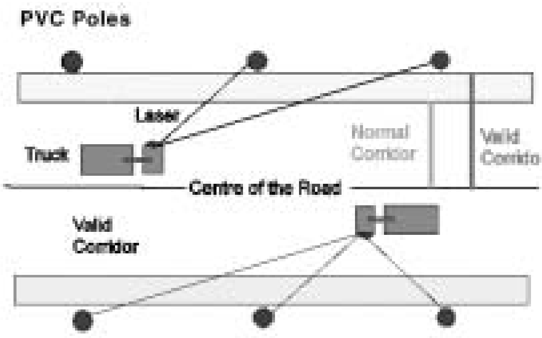


Figure 7: Schematic illustrating how a truck monitors the infrastructure to determine its position across the road.

The system logs 12 hours of real-time information relating to the position of the truck in relation to the road as well as time stamped alarm events and raw sensor data for the last period of operation.

Field trials of this system have been completed at Comalco's Weipa mine. The mine was sufficiently impressed by the performance of this technology that they are currently negotiating to purchase 13 of these systems for their truck fleet.

Haul Road-truck Monitoring System

The term 'road roughness' refers to variation in a road surface profile that induces unwanted vehicle vibrations. These vibrations accumulate to fatigue both the vehicle and the driver. In particular they contribute to chronic lower back-pain, which continues to be a significant workplace heath and safety issue.

One of the projects currently being undertaken in the Division of Mechanical Engineering at The University of Queensland is to develop and test a technology that allows the truck sense the quality of the haul road that it runs on with a view to reporting when the road has deteriorated to the point where repair should occur.

The principle determiner of haul road quality is the level of deviations of the road from its designed form at the characteristic dimensions which affect vehicle dynamics, ride quality, and dynamic loads. Over a typical section, the road profile can be viewed as a sum of sinusoidal waves of different length, amplitude and phase. The different wavelength produce different vehicle vibrations ranging from heaving, caused by long wavelengths, to sharp impacts and jarring caused by short wavelengths, such as might be associated with spilt rock or potholes.

Associated with these vibrations are forces that are initiated at the tyres and which propagate through the vehicle structure, fatiguing components of the truck and reducing ride comfort. As a general rule, the intensity of these forces increases with increasing road roughness, vehicle speed, and vehicle mass (mass here changes when the vehicle is carrying a payload). It is to be recognised that different vibrational frequencies will affect the driver in different ways and to different extents, as will different levels of force at those frequencies.

Work in this project has two streams. The first has been the development of a virtual mining truck that models the Caterpillar 785B using ADAMS dynamic modelling software. This virtual mining truck can be driven over arbitrary road profiles and is capable of accurately replicating motions that the driver would experience and then correlating these with road surface quality.

The second stream of the work focuses on estimating the forces acting at the interface between tyre and road (Figure 8) and then using these forces as statistical classifiers of road quality. These force estimates can be made using the sensors already fitted to existing trucks as part of the general management haulage systems, augmented by a small number of inertial sensors (accelerometers and rate gyroscopes).

To date the technology for force estimation has been tested by using the virtual mining truck as a proxy for a real mining truck and it has been demonstrated that road surface quality can be established accurately from estimates the road-tyre interaction forces. This work is described in Siegrist (2003). The next phase of the work is the implementation and testing of the tyre force technologies on a physical truck. This work is currently underway.

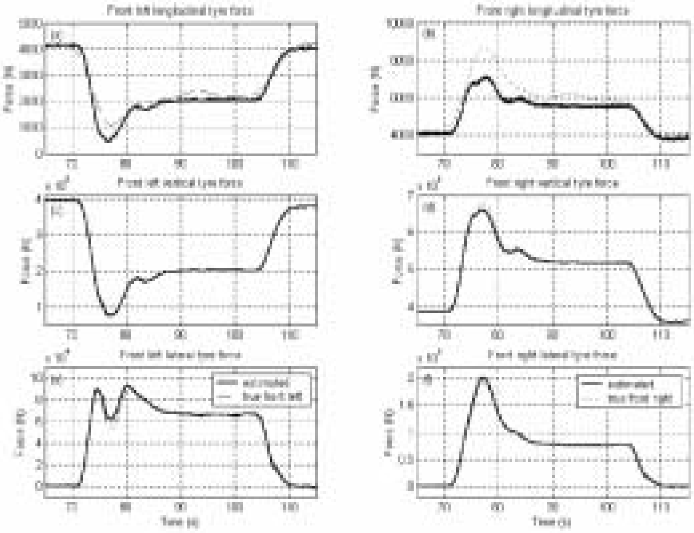


Figure 8: Plots of tyre force estimates during a coast down manoeuvre. The broken line is the true force, the solid line the estimated forces.

Proximity Sensor for Trucks

Figure 9 illustrates the damage caused when an off road haul truck runs over a light vehicle. Unfortunately, because of the poor driver visibility in these large trucks, this type of accident occurs all too frequently with, often fatal, results. The U.S. National Institute for Occupational Health and Safety (NIOSH) has reported that well over 100 incidents of off-highway trucks driving or backing up over pedestrians or light vehicles occur in the United States each year, resulting in over 20 deaths.

A commercial product has been developed to address this problem. This system is based on radio tags; however it may be too passive to guarantee the level of warning that needs to be generated.

CMTE's Sydney University researchers have started a new project with Phelps Dodge to demonstrate the reliability of using a variety of sensors to monitor movement in the truck blind spots.

Figure 9: Damage inflicted on a light vehicle when run over by a haul truck.

Virtual Reality for Operator Training

Virtual Reality (VR) is a simulator. The person experiencing VR is surrounded by a three-dimensional computer generated representation – a virtual world. They are able to move around in this world and see it from different angles; they can reach into it, grab it, and reshape it.

VR multimedia training, an example of which is shown in Figure 11, can dramatically reduce the cost of delivering training by decreasing learning time for trainees and instructors. It obviates the need for expensive and dedicated training equipment (physical mock-ups, labs, or extra equipment for training purposes), and travel expenses. Perhaps most significantly, it reduces the need to take multi million dollar machines out of service to conduct in-the-seat training. This approach is finding increasing commercial application, see, for example, Williams, et al, 1998.

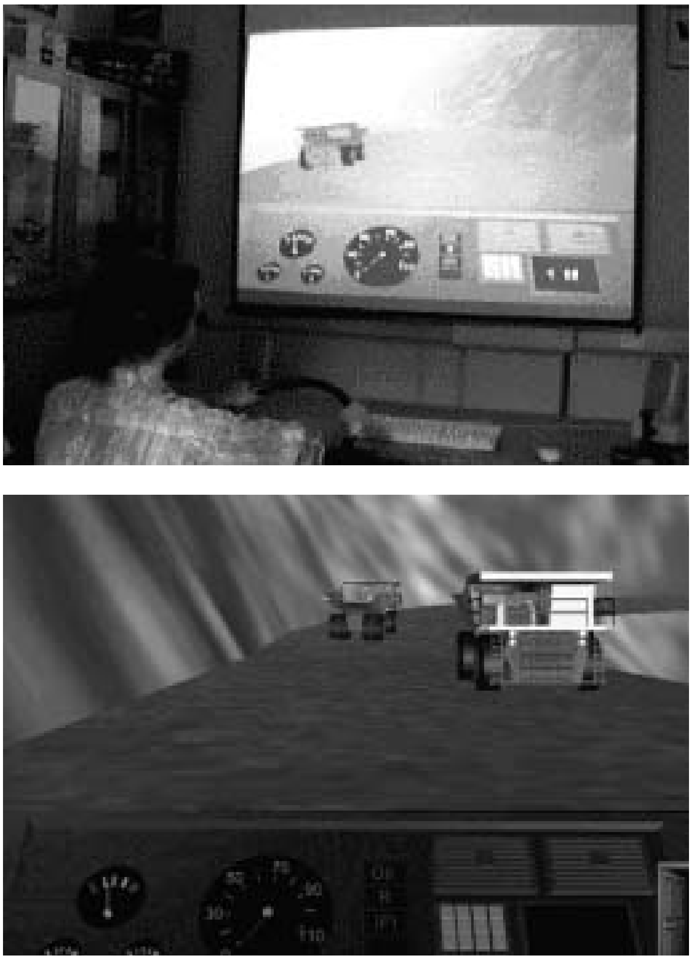


Figure 11: AIMS' open pit truck simulation VR model, from Williams et al, 1998.

The University of Queensland's VR research group has developed a virtual barring down simulation system to provide improved hazard identification training for underground workers, primarily in relation to rock related hazards during barring down exercises. The major aims of this simulation are to:

- Expose a trainee to various hazardous situations without actually risking his/her live
- Take the trainee through a mine and test his/her ability to do a risk assessment in hazardous situations whilst tracking his/her individual scoring progress

- Provide training in highly dangerous operation of scaling down rocks.

The trainee is required to successfully negotiate his/her way around the model identifying the hazards and selecting appropriate corrective actions (Figure 12).

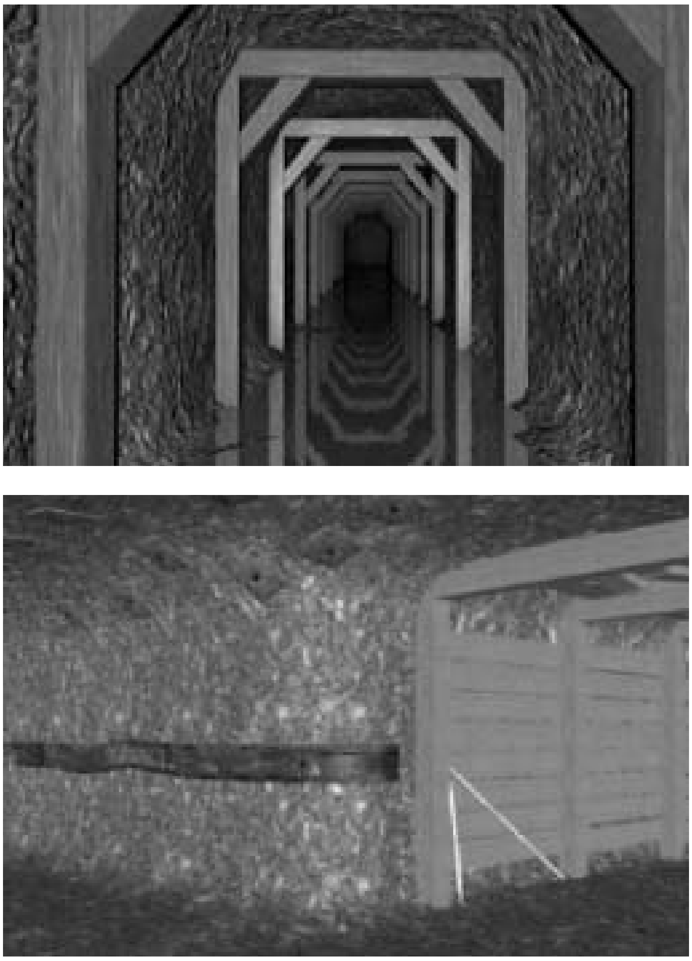


Figure 12: Barring down simulator.

Conclusions

A wide range of safety-related technologies are being developed at The University of Queensland and its related research centres. Some of these technologies are in an advanced state of development and are already being adopted by industry. Others, are still in the research and development stage. All show promise in helping to improve the safety performance of mining operations.

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Using Data to Identify Risk to Improve Safety & Health Performance

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Abstract

Using Data to Identify Risk to Improve Safety & Health Performance

The New South Wales Department of Mineral Resources objective is to use data and information to undertake a detailed analysis of incidents and accidents to identify risks so that the predictable can be foreseen and avoided.

The Department of Mineral Resources has established a computerised data base called COMET (COmmon Mines EnvironmenT) to capture information on accidents incidents, inspections, audits and accreditation in improving safety and environment performance.

This data together with data from Coal Mines Insurance and WorkCover N.S.W is being used to provide trend and comparison information.

The NSW Injury Risk Management Research Centre at the University of NSW has been engaged by the Department to collate and prepare a detailed analysis of the data.

Through this process, five areas have been identified for further research. These being:

- Electrical energy
- Mechanical equipment
- Work environment
- Hours of work
- Contractors involvement accident and incidents.

The paper covers:

- The establishment of a mix of performance measures for the industry to indicate whether the safety performance is improving
- The provision of data to provide useful comparisons and benchmarks against which companies can compare performance
- The development of positive performance measures
- The findings and outcomes of the detailed analysis of electrical energy shocks
- The provision of information to industry
- An outline how the data is being used to determine departmental operational priorities
- Future plans to undertake research into the other areas identified.

Introduction

The development of performance measures in occupational and health and safety as a means of indicating whether the standard of performance is improving is not novel or innovative. The more recent debate has been about what are the most effective and relevant measures to show the true performance of occupational health and safety management.

The major review into Mine Safety in New South Wales conducted in 1997 by ACIL Economics and Policy Pty Ltd was extremely critical of the credibility of traditional measures such as Lost Time Injury Frequency Rate. It recommended that the appropriate measures should be a combination of those which measure the process in place to manage major risk and prevent serious injuries and death as well as measures safety outcomes. As a result, a recommendation was made to adopt a mix of measures that might include traditional measures as well as new measures such as disabling injury and the action taken to manage core risks together with a new set of measures to be defined to enable individual sites to determine their safety performance.

A great deal of progress has been made in this field with a wide suite of industry performance measures being adopted and steps being taken to adopt a consistent approach by the various jurisdictions across Australia through a National Mine Safety Framework.

Industry has been encouraged to adopt a range of positive performance measures to look at what proactive action is being taken to prevent accidents and incidents.

The development of a wider selection of performance measures and the adoption of positive performance measures has assisted in the understanding of occupational health and safety performance and has enabled trends to be identified and comparisons to be made. It has, however, been limited in undertaking a detailed analysis of the actual risks and causes of poor performance that arise out of accidents and incidents.

This is the task that the New South Wales Department of Mineral Resources (DMR) is endeavouring to undertake. The objective is to analyse incidents and accidents to identify the risks so that the predictable can be foreseen and avoided.

This paper traces through the establishment of a data base by DMR called COMET (Common Mines and EnvironmenT) which records mine accidents and incidents and looks at how reports from the database provide trend and comparison information which has been used to identify areas for more detailed research.

One of the areas of risk identified has been electrical energy. The first in-depth analysis of 110 electrical shock incidents has been undertaken and the methodology and the results are presented.

DMR Data Base

The Data Base COMET (COmmon Mines EnvironmenT) collects data/information on mines, events such as accidents and incidents, inspection audits, accreditations and environmental issues. The system commenced collecting data in April 1999.

The COMET information system captures and manages data to support:

- Business objectives and strategy by providing data and information to improve health and safety performance in the NSW mining industry
- Corporate and business reporting requirements.

Industry reporting requirements are underpinned by the administration of the relevant mining legislation.

Events are the core component of COMET and reflect the essential business processes of the Division. They are the important link between mines and participants.

Events capture core data on event type, event subtype, date/time, organisation, event status, event priority and event participants. Documents (Excel & Word) can be attached to each event.

Data entered from incident and accident events includes location of the event, type of event (this relates the event to the relevant clause of the legislation), whether injuries occurred, property was damaged, equipment was involved, whether the mine manager's report was adequate, whether a more detailed report is required, whether a full investigation is required, circumstances surrounding the incident, apparent causes of the incident, actions taken and potential breaches.

The capacity of the COMET information system to capture the data detailed above, enables trend analysis and causal factors of incidents and accidents, to be identified, so that safety strategies can be developed, implemented and communicated to the mining industry, to influence systems, work practices, behaviour and culture.

A screen shot of one example of the COMET information system is highlighted in Figure 1.

COMET is also used to help set priorities so that DMR can identify where its resources can be best focused to improve safety and environmental performance.

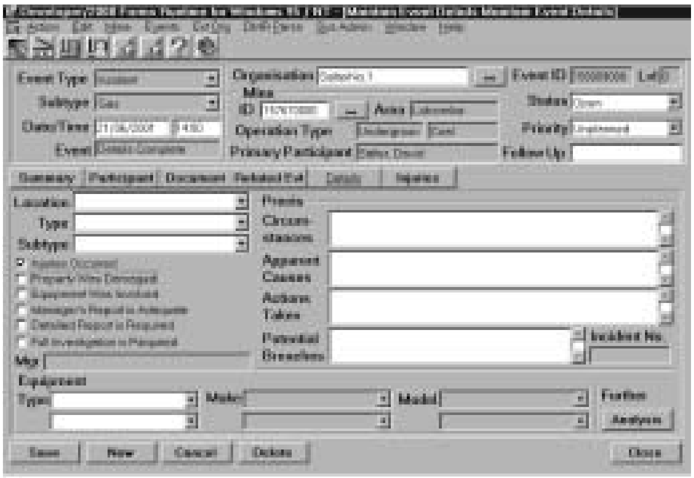

Figure 1: Example of a COMET Screen Shot.

Industry Performance Measures

From the Mine Safety Review referred to earlier, a comprehensive set of performance measures have been introduced.

These cover such traditional measures as:

- Fatality rates
- Lost time injury rates
- Serious injury
- Severity and duration rates
- Reportable occurrences
- Workers compensation information as to claims and cost
- Enforcement action directions and notices
- Prosecutions.

Some newer measures that are being used cover:

- Near miss
- Permanent disability
- Medical treatment
- Total recordable injuries
- Assessment of culture usually by survey.

Lead or Positive Performance Measures

Traditional outcome-based OHS performance measures have been criticised as being retrospective and backward looking. They do not provide any indication of how risks are being measured and what steps are being taken to address risk. On this basis, a deliberate move has been made to include a mix of lead or positive performance measures. These measures are used to gain an understanding of the actions being taken which are likely to reduce the risk of accidents and incidents.

The Minerals Council of Australia in their Practical guide to Positive Performance Measures (PPM) 1998 defined PPM as a measure of a proactive leading activity necessary to control loss and damage. It is an upstream process measure rather than a downstream outcome measure. Some of the positive performance measures put forward for site use by the Minerals Council of Australia include:

INTENT or TARGET	DEPLOYMENT – PPM
All operational hazards identified and managed	% risk assessment completed % control measures implemented
Standard work practices in place for critical activities	% ISA/SWPs completed for critical activities
Employees working safely	% safe behaviour observed, eg: PPE compliance
Provide safe & healthy place of work	% schedule inspections completed % actions arising complete
Safe and competent employees	Scheduled training completed % incidents with training identified as major contributor
Implement lessons from hazard/incident reports	% incident investigation completed on time % corrective actions implemented
Improve safety climate	Overall findings on criteria
Involve employees in regular tool box meetings (TBM)	% scheduled held % employees attending % actions arising completed

Table 1: Positive Performance Measures.

In addition to these measures the Department of Mineral Resources is looking at a range of positive performance in terms of measuring:

- The completeness of Mine Safety Management Plans
- An assessment by use of a test of the consultative process at the mine site
- Assessment of induction programmes
- Review and follow up of findings of assessments and audits.

It is expected that feedback to industry on these measures will provide encouragement to understand and pursue these activities which will make a contribution to risk management and result in positive safety performance outcomes.

National Mine Safety Framework

One of the goals arising from the establishment of a National Mine Safety Framework is to develop consistent and reliable mining OHS performance data collection analysis and distribution.

The objective is to obtain consistency across the jurisdictions which will enable:

- Comparison of data and performance
- Identification of trends
- The effective and efficient targeting of resources
- Development of proactive coordinated approaches to industry issues.

New South Wales is fully committed to participating in this process to share and exchange data and information.

Performance Reports

Initially the COMET and Workers Compensation data was used to provide reports on trends and comparisons. However these reports were very limited in their capacity to provide the reasons for movements.

The data largely identified potential problems and improvements without a great deal of understanding as to the forces at work. The assessment of these changes was largely based on the experience of those working in the industry. It could be said that the data raised more questions than they answered.

These reports were provided to the Mine Safety Advisory Council being the principal advisory body to the Minister for Mineral Resources and while the content of the reports improved they were not providing the quality or content desired.

To provide more meaningful information, the NSW Injury Risk Management Research Centre (NSW IRMRC) was engaged by DMR to provide an analysis of safety performance data. The Centre brought a level of expertise and independence which added identifiable improved value to the reporting. They commenced the first analysis of information in June 2001 using data collected from COMET since April 1999.

The analysis undertaken by the NSW IRMC covered both trends in a number of specific indicators and an indepth examination of relationship between events in each sector.

The analysis considered trends in the number of events and persons recorded in the COMET data base and looked at trends in injury and non injury for the Coal and Non-Coal sector as to the types of events, mine operator region, types of injury, characteristics of persons injured, the agent, mechanism nature of injury and part of body injured.

The analysis was undertaken of the following range of performance measures for the coal and metalliferous sectors and mine operation types:

- Lost time injury frequency – numbers, rates and trends
- Severity level – numbers, rates and trends
- Body part injured
- Nature of injury
- Mechanism of injury
- Agent of injury
- Types of incidents and events
- Characteristics of persons injured including occupation, employment type, age
- Relationships between type of injury, event subtype and mine operation
- Relationships between type of incident, event subtype and incident subtype
- Enforcement notices including the number and the relationships between the application of the DMR's enforcement mechanisms and changes in mine safety performance indicators
- Where possible benchmarking information will be provided which will allow comparisons with other states in the mining sector and with other industries.

A further analysis has looked at frequency and incidence rates, compensation claims and distribution of incident and mine type. The area which was of particular importance as to possible links to causation related to the characteristics of injuries, reviewing the data from 1 July 99 to June 2002. Changes over the period showed:

- Fractures have increasingly been the most common type of injury, followed by other and unspecified injuries which also increased over the period, whereas the percentage of acute sprains and strains of joints and muscles, showed a clear decrease over the three year period
- The percentage of cases with injuries to the hip, back, spine or pelvis decreased markedly with more injuries reported as general/unspecified. As the percentage not recorded also increased over the time, these changes may be due to coding problems
- Analysis of the mechanism of injury showed an increase in the percentage of reports of contact with electricity and a slight decrease in the reporting of being hit by moving objects and multiple/unspecified mechanisms (see Figure 2)
- General machinery and fixed plant, mobile plant and underground work environment have been the most common agency of injury over the three years, with the percentage of cases involving general machinery and fixed plant increasing and the percentage of mobile plant decreasing over the period
- The main types of events over all years have involved electrical energy, work environment, mechanical mobile equipment and strata control (see Figure 3). Most notably, the percentage of electrical energy events has trebled and the percentage of strata control events has doubled over the three years. On the other hand, percentages of work environment and mobile mechanical equipment have decreased
- Analysis of the types of persons involved in events reported to COMET shows an increasing percentage of 20 to 29 year olds but little change in the distribution of occupations or contractors over the period. Contractors made up a significant minority of around 20% of injury cases for both sectors and all mine types (see Figures 4 and 5).

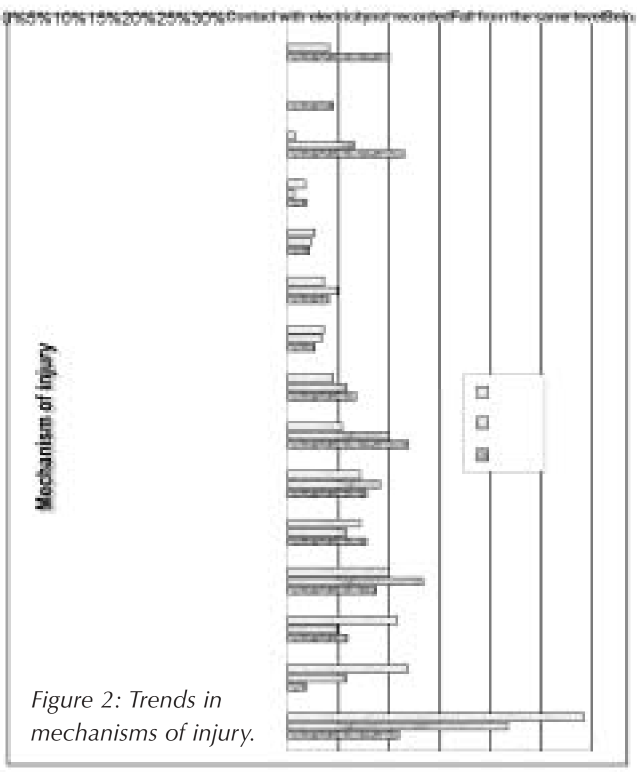

Figure 2: Trends in mechanisms of injury.

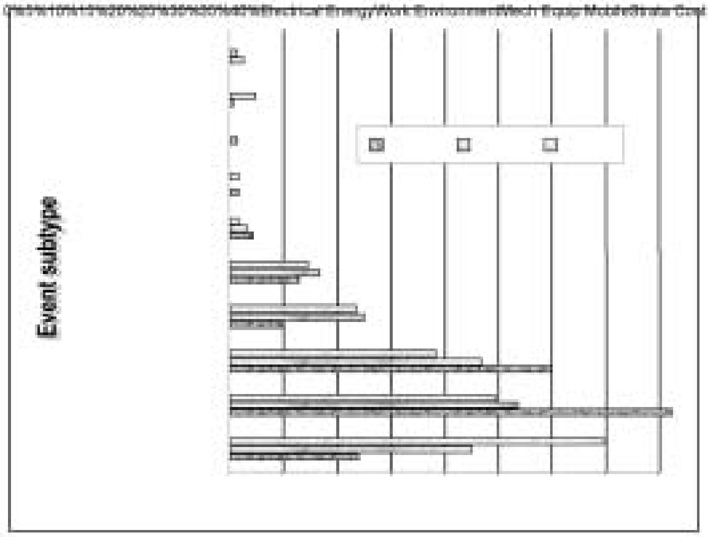

Figure 3: Event Subtype.

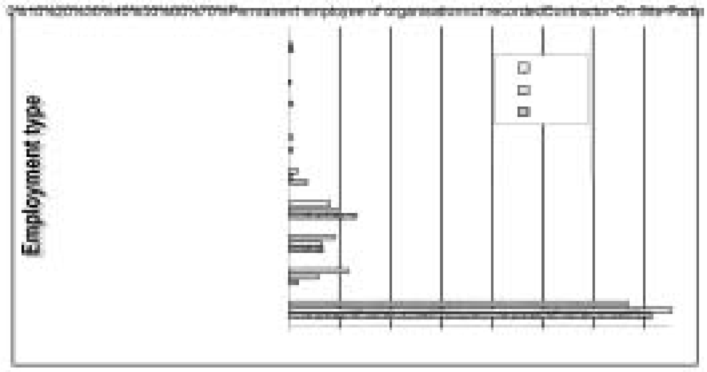

Figure 4: Trends in type of employment.

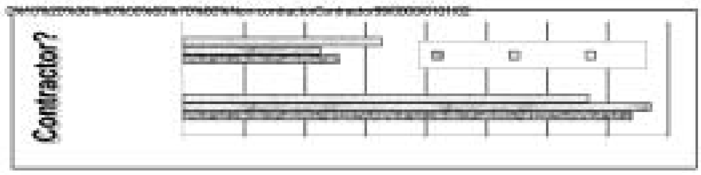

Figure 5: Trends in numbers of contractors injured.

Detailed Analysis of Events/Incidents

The analysis of the COMET database provided background information that helped to identify the most important high risk areas for further in-depth examination.

In addition, the Mine Safety Council then established a Performance Measures Task Group to review the available information on trends in mine safety performance and to identify areas for further analysis and research.

Based on the analysis of the mechanism of injury event and trend data the Task Group identified a number of areas for further in-depth analysis and research. These were:

- Electrical energy incidents
- Mechanical equipment incidents
- Work environment incidents
- Accidents/incidents involving contractors
- The issue of hours worked.

No data was available to identify hours of work as an issue but anecdotal evidence and the experience input from the tripartite safety advisory committees for the various mining sectors supported the five areas nominated and these were endorsed by the Mine Safety Advisory Council.

Electric Shocks Analysis

Identification of Cases

For this analysis 122 cases involving electrical energy-related outcomes were located in the Department of Mineral Resources database. Most of these cases were in the database because they were Notifiable incidents under the Coal Mines Regulation Act (39.7%), Dangerous Incidents under the Mines Inspection Act (16.5%) Incidents (14.0%) or High Potential Incidents (12.4%). About half of the cases involved a degree of electric shock (55.74%), but only a few resulted in serious injury or lost time(3.2%). Most cases occurred at underground mines (51.6%), with the remainder occurring at open cut mines (33.6%) or at processing plants (13.9%). Most of the cases occurred in coal (62.3%) compared to minerals mining (35.9%).

Coding of Cases

For each case in the sample of 122 cases the information available in the COMET database as well as Electrical Inspectors reports were coded and classified using a framework previously used to classify and code occupational fatalities (Williamson and Feyer, 1990; Feyer and Williamson, 1991; Williamson, Feyer and Cairns, 1996; Williamson and Feyer, 1998). This is illustrated in Figure 6 Classification framework for electrical incidents. In collaboration with a group of experts (DMR Electrical Inspectors), some modifications were made to the framework to make it more suitable for coding the information available on electrical energy events. Only 12 cases were unable to be coded as too little information was available on the causes. The reliability of coding was checked using a second coder for a sample of cases. The coding was found to be reliable, with 86.9% cases being coded in the same overall manner by both coders.

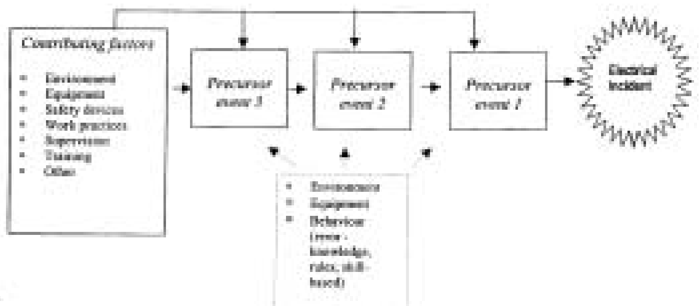

Figure 6: Classification framework for electrical incidents.

Results of Classification & Coding

Contributing Factors:

Contributing factors are defined as factors that made a contribution to the incident occurring but were pre-existing, sometimes for very long periods, in the time before the incident occurred. Table 1 lists the Contributing factors which played a role in the circumstances of the electrical incidents for the subsample from the COMET database.

Ninety percent of cases involved equipment factors in some form. Approaching half of the cases involved equipment alone, mainly due to design features (eg: problems relating to equipment not being fit for purpose) or other aspects of poor design. Design or breakage of equipment were the main problems overall, both as single factors alone and in combination with other factors. In fact poor or inadequate design was a problem in more than half of cases (55.1 %) and equipment breakage was a problem in 46.2% of cases. The most common single patterns of contributing factors were equipment design which accounted for 14.5% of cases, followed by the combination of equipment design and breakage (11.8% of cases).

Equipment problems due to poor installation were less common, and occurred in only 13.6% cases and mostly in combination with other factors especially work practice factors, in particular unsafe or inadequate standard operating procedures. Poor installation of equipment was the sole factor in only three cases.

Work practices were a contributing factor in around one-third of cases overall (31.8%) and were mainly due to unsafe standard operating procedures (23.4%) and, to a lesser extent, problems with housekeeping (9.0%). Work practice problems hardly ever occurred as a sole factor (only 5.5% cases) and mainly involved continuing use of a piece of equipment that was poorly designed or broken, or not doing the housekeeping or maintenance to fix the equipment.

Environmental factors were also important contributing factors and in all of these cases this was due to the presence of water. Notably though, environmental factors only really played a role in combination with equipment factors and not work practice factors. Only two cases involved a combination of a wet environmental and inadequate or unsafe work practices.

Overall, therefore, the main types of Contributing Factors were due to equipment problems, with design factors and equipment breakage being the biggest single factors. Very few cases involved problems due to installation alone, although it was important in a significant proportion of cases in combination with other factors especially unsafe or inadequate work practices. Wet mine environments contributed to the incident almost always in combination with equipment design problems or breakage.

Precursor Events

Precursor Events are defined as the events leading most immediately to the incidents occurrence. They are linked with the incident in time, but they are distinguished by a much shorter time frame than for Contributing Factors.

The pattern of involvement of precursor events is shown in Table 2. Most cases involved an environmental event relating to the mine environment or location of the person at that point in time and relatively few resulted from a person's behaviour. Equipment breakage just before the incident was very rare. Specifically the results showed that:

- In most cases the most direct cause of the incident was due to a person coming into a situation where they could be exposed

to electrical energy (90.7%) and in three-quarters of incidents there were no other immediate causes
- A significant number of cases involved water getting into the person's location Just before the incident (13.7%)
- In the majority of cases behavioural failures were not involved at all (80% although for most cases the event sequence occurred when the person's behaviour placed them into the location where they made contact with electrical energy. In these cases, however, the behaviour was not an error
- In a relatively small number of incidents the person made an error and this led to them making contact with electrical energy (19.1%). In most cases the error involved the person failing to apply a known rule, usually not isolating the equipment they were working on at the time and consequently making the situation safe
- Very few incidents involved equipment breaking just before the incident (4.5 %).

Table 2: Types of Contributing Factors involved in 110 cases resulting in exposure to electrical energy in mining.

Type of Contributing Factors	*n*	*%*
Equipment factors only	**45**	**40.9**
Design only	16	14.5
Installation only	3	2.7
Breakage only	10	9.1
Design and breakage	13	11.8
Design and installation	1	0.9
Design, installation and breakage	2	1.8
Equipment and Environment factors	**19**	**17.3**
Design and Environ (water)	7	6.3
Breakage and Environ (water)	6	5.5
Design, Breakage and Environ (water)	4	3.6
Installation, breakage and Environ (water)	2	1.8
Equipment and Work practice factors	**27**	**24.5**
Design and standard operating procedures	6	5.4
Design and housekeeping	1	0.9
Design and supervision/coordination	1	0.9
Installation and standard operating procedures	4	3.6
Installation and housekeeping	1	0.9
Breakage and stand operating procedures	3	2.7
Breakage and housekeeping	4	3.6
Design, breakage and stand operating procedures	3	2.7
Design, breakage and housekeeping	2	1.8
Design, installation and supervision/coordination	2	1.8
Environmental factors only (water)	**1**	**0.9**
Environment and Work practice factors	**2**	**1.8**
Work practice factors only	**6**	**5.5**
Housekeeping	1	0.9
Standard operating procedures	5	4.5
Equipment, work practice and Environment factors	**6**	**5.5**
Design, standard procedures, water	3	2.7
Design, housekeeping, water	1	0.9
Breakage, standard procedures, water	2	1.8
No contributing factors	***4***	***3.6***
Total	***110***	***100***

Table 3: Types of precursor event involved in 110 cases resulting in exposure to electrical energy in mining.

Type of Precursor Event	*n*	*%*
Behaviour only	**7**	**6.4**
Skill-based error	2	1.8
Rule-based error	4	3.6
Violation	1	0.9
Environment only	**84**	**76.4**
Environment voltage	69	62.7
Environment water	8	7.3
Environment water ′ Environment voltage	7	6.4
Environment and Equipment	**4**	**3.6**
Breakage ′ Environment	4	3.6
Environment and Behaviour	**14**	**12.7**
Skill-based error ′ Environment	3	2.7
Rule-based ′ Environment	9	8.2
Knowledge-base ′ Environment	1	0.9
Violation ′ Environment	1	0.9
Behaviour and Equipment	**1**	**0.9**
Breakage ′ Rule-based	1	0.9
Total	***110***	***100.0***

Patterns of occurrence of Contributing factors and Precursor Events

Table 3 shows a summary of the relationships between Contributing Factors and Precursor Events.

By far, the most common pattern involved pre-existing problems with equipment leading to a person inadvertently being exposed to electrical energy. Specifically the findings showed that:

- Unsafe work practices, including poor housekeeping played a much smaller role overall than equipment problems
- Where work practice problems occurred they contributed to incidents that involved both a person's behaviour and characteristics of the environment at the time of the incident
- Very few incidents occurred due to a person's behaviour just before the incident, although behaviour was important, as unlike the other types of events or factors, behaviour could be the sole cause of electrical incidents
- Equipment and environmental events and factors were never the sole cause of the incident
- Where an event was due to a person's behaviour. it mainly involved an error due to not applying a known rule (such as failing to isolate equipment before beginning work), and mainly in combination with pre-existing problems of equipment design and or breakage at an earlier time.

Differences between Different types of Mine Operations

Electrical incidents occurred for similar reasons across all types of mines. Equipment factors both alone and in combination with other factors were the most common contributing factor and work practices were far less common in all types of mining operations. For all mine types the location of the person at the time making them come into contact with a source of electricity was the most common type of event leading directly to the electrical incident. The major differences were:

- For the non-coal sector, the second most common event involved the person's work environment being wet
- For the coal sector, the second most common type of event leading to the electrical incident was due to a person's behaviour in the form of a failure to apply a known rule.

Summary of Electric Shocks Study

This study involved an in-depth analysis of 110 electric shock incidents reported to the NSW Department of Mineral Resources COMET database. Most of the cases were reported as Notifiable incidents and did not result in serious injury or lost time. Most occurred at underground mines and around two-thirds came from the coal sector. All cases were coded using a classification and coding system developed to look at the causes of occupational fatalities. Evaluation of the reliability of the coding showed good reliability.

The most common patterns of occurrence of the electric shock incidents involved the following:

- Almost all cases involved equipment factors mainly in the form of inadequate design or breakage
- In almost all cases, the equipment failure was a pre-existing condition. Breakage of equipment just before the electric shock was very uncommon
- The behaviour of mine workers played a minor role in these incidents. In most cases, the person inadvertently made contact with equipment which was already unsafe electrically. In this way, the person's role was an indicator that a problem existed, rather than the person making a contribution to the problem occurring
- Where an error occurred, it was mainly a rule-based error involving failure to isolate or check for dead. In all these cases, there was a pre-existing fault with the equipment which a check would have detected
- Water was also a factor in a significant minority of cases, especially in the non-coal sector. Where water played a role, however, it always occurred in combination with equipment design problems or breakage.

These patterns highlighted directions for prevention of electric shocks in mining. Most obviously, they show that almost all of the incidents could have been prevented by audits, reviews and maintenance of mining equipment. The results show strongly that an on-going safety review system would be the single, most effective intervention to prevent electric shock incidents. The results also point to the need to reinforce among mine employees and contractors the importance of fundamental electrical safety procedures including isolating and checking electrical equipment. This is important both because it is good safety practice, but also because, as the results of this study show, mine employees and contractors cannot be sure that the equipment they are using is safe.

Overall, this project has shown the value of in-depth analysis for identifying the causes of safety-related incidents and the strategies most likely to be successful in preventing them.

Implementation

To maximise the learning from the analysis and benefits flowing from the findings, from the electric shocks analysis, a meeting was held between the Electrical Inspectors, Senior DMR staff and the Director NSW IRMCC to develop a detailed implementation plan.

In summary the plan covers:

- A communications strategy was developed to communicate the recommendations of the electrical shock report to target industry groups including Electrical Consultants/Contractors, Local Supply Authorities, NECA, Regional Seminars, Workcover, Dept. Fair Trading, HEISN (Hunter Industrial Electrical Safety Network), NECA (National Electrical Communications Association), seminars, conferences and district check inspectors. A safety alert will also be issued
- There will be a review of the data capture and recording processes to be more closely aligned with precursor events and contributing factors
- Impact upon legislation to be considered as far as applying a "Industry Code of Practice"
- Monitoring of the implementation of the recommendations from the electrical shock report by safety operations
- The development of a "Factsheet" to highlight the learnings and recommendations of the report.

The implementation plan was endorsed by the Performance Measures Task Group and agreed to by the Mine Safety Advisory Council.

At the time of writing the plan is being implemented and the second project covering mechanical equipment is about to start.

Conclusion

A considerable effort has been directed to the development of a comprehensive set of performance measure to enable trends and comparisons to be made both within the industry and outside.

This information has enabled areas to be identified where further detailed research needs to be conducted with the objective of establishing what is known about risk factors in mining, or what can be predicted and then developing approaches for avoiding them or preventing them from occurring.

DMR has used the analysis of trend data to identify major areas of concern and has had conducted an indepth analysis as to factors leading to causation.

The learnings from the first analysis are being fed back to industry in a practical way to ensure that the industry is informed as to the appropriate action to be taken to address the findings.

The approach of the Department is that unless the data/information produced is used to change systems, procedures, equipment or behaviour, one has to question the benefit of the data.

The outcome of this methodology does raise the question as to whether specific performance measures should not exist in relation to specific hazards with high priority such as electrical energy.

The results of the analysis into the other areas identified namely, mechanical equipment, physical work environment, contractors involvement in accidents and incidents and hours of work are awaited with high expectations of providing valuable information to the industry to help manage risks.

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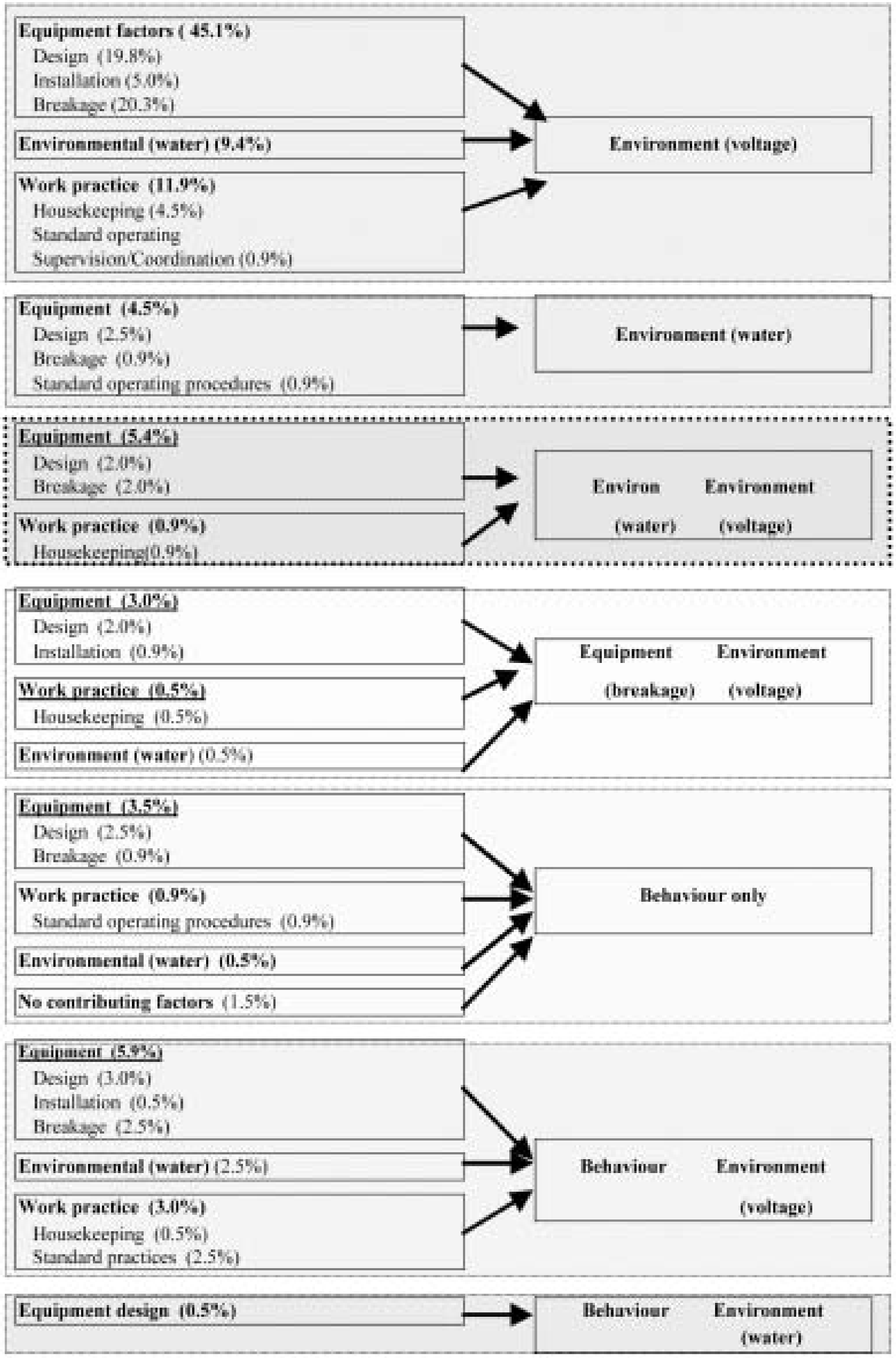

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ACARP – Accepting the Safety Challenge

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ACARP

The transfer of the collaborative research effort for the Australian black coal industry from a Commonwealth Government administered scheme to an industry managed program took place in 1992. The program, Australian Coal Association Research Program (ACARP), has committed approximately $110 million of direct industry funding towards over 670 projects in that time.

The "charter" for ACARP is identified in two forms, one being the undertaking to the Commonwealth Government in a Memorandum of Understanding (MOU) with respect to the overall objectives of the program, the other being identical contracts with each coal producer for the governance of program management and administering the levies collected.

The MOU states that the program was established for the purpose of;

- Providing strategic leadership to industry R&D and to act as a catalyst to stimulate R&D interest within the coal and associated industries
- Improving the management and application of coal research in Australia
- Ensuring the more effective use of Australia's black coal resources
- Increasing the economic, environmental, safety and social benefits to the industry and the wider community
- Promoting the competitiveness, sustainable use and management of Australia's coal resources.

The emphasis within the objectives has changed in the period but the overall concept has stood the test of time and has sufficient flexibility within the boundaries to adapt to the industry's needs.

It is this flexibility that allows the program to respond to the changing issues as they face the industry. Ten years ago the results of the then Moura Enquiry were at the front of the list. These outcomes continue to drive improvements to mine communication, exploration techniques and support for aided and self rescue. However the program is also responding to the community's concern over greenhouse gas emissions. This area was certainly not considered to be a likely candidate for collaborative research dollars when ACARP was originally established.

The flexibility has increased over the past ten years as the administrative overheads were reduced and the industry formed technical committees became more confident in taking the reins from the research community and driving the direction of industry funded research.

The direct industry commitment of $110 million represents about $450 million of leveraged funding in total. This leveraged amount, traditionally about $3 total to $1 direct ACARP funding due to contributions from other sources (cash and in-kind support from industry employees/companies and research organisations), has been significantly increased in recent times as a result of formal participation in two Co-operative Research Centres, CRC for Coal in Sustainable Development (CCSD) and CRC for Greenhouse Gas Technologies (CO2CRC).

The program mechanism relies on its strength of technical and financial leverage provided by coal industry organisations at all levels of the process to achieve outcomes for the industry. It is ably supported by world ranking researcher competence to the extent that the level of Australian technical know-how as applied to all aspects of the exploration, production and use of coal is up with the best, if not the best, in the world. Fifteen to twenty years ago the Australian coal industry still relied heavily on imported technology. ACARP has played an important role in bringing about the changed position.

Australia is now seen by International OEMs as a credible source of technology. Equipment manufacturers have enthusiastically joined the reborn Co-operative Research Centre for Mining Technology and Equipment (CMTE) in its new format as the CRC for Mining, including P&H, Mine Pro Services and Komatsu Australia. The Longwall automation project, which is being driven by an ACARP steering committee, enjoys the strong and interactive support of both major longwall manufacturers, Joy and DBT. Whilst ACARP will never have sufficient funding nor a desire to pay fully for the necessary developments needed to ensure safer and more efficient equipment, the early investment of industry input through ACARP seed funding is ensuring Australia does get heard.

Late last year it was considered appropriate to have an industry assessment of the value of its own program and views were canvassed from those directly concerned. Some examples of testimonials provided include the following;

"The collaborative support of ACARP and AMIRA for blasting research at the JKMRC has ensured that Australian mines have access to world-class blasting technology."
Professor Don McKee, Director
SUSTAINABLE MINERALS INSTITUTE

"The application of the coal loss measurement techniques developed through ACARP has assisted our managers in understanding, measuring and reducing coal loss. If we're to advance mining technology and continue to drive down the cost of producing coal, it's critical that ACARP continues to support work on the more difficult problems faced by mining operations."
Bob McKerrow, Mining Operations Manager
THIESS PTY LTD

"ACARP plays an important role in investing industry research funding in the future technologies. Without this investment Australia will inevitably lose the competitive edge that comes with having access to the most advanced coal treatment technology in the world."
Russell Kempnich, Executive Chairman
SEDGMAN PTY LTD

"Our operations have benefited greatly from the sustained investment in developing the enabling technologies. The cumulative benefit of this ongoing investment is progressively improving plant efficiency while driving down costs."
Dr Richard Peck, Coal Technology Manager
ANGLO COAL AUSTRALIA PTY LTD

"The ACARP program has produced a significant body of research that is of high quality by international standards—some of which is outstanding. Geomechanics practice in the Australian coal industry compares favourably with that of the civil engineering and metalliferous mining disciplines."
Coal Geomechanics Review, September 2001
Professor Ted Brown AC
GOLDER & ASSOCIATES PTY LTD

"The developmental work and long-term commitment that ACARP has invested in erosion studies have led the industry. The research has provided the supporting science and confidence necessary to commit the large expenditure associated with reshaping dragline spoil piles."
Rob McNamara, former General Manager—Environment
MIM HOLDINGS LIMITED

"Over the past 10 years, the performance of a 50m3 dragline has moved from an average of 11 million BCM to around 16 million BCM. This improvement is due to many factors. However, without the early investments in research made by ACARP and others, many of the wins with bucket and rigging design, operating control and productivity measurement would not have been achieved."
Mal Lees, Chief Technologist
PACIFIC COAL PTY LTD

"Productivity increases can be attributed to the cumulative effect of ACARP projects in conjunction with supporting industry innovation and industrial rationalisation. The UDD dragline modification will demonstrate the value of long-term investment in dragline research and the contribution that ACARP funding has played in developing this research capability."
Cam Davidson, Project Development Manager
BHP BILLITON MITSUBISHI ALLIANCE COAL OPERATIONS PTY LTD

Safety Component of ACARP

Identification of occupational health and safety features of ACARP commitment and success is not simple to extract. Largely due to the structure for managing the process of project selection the usual method of reporting summary of funds commitments is by the five technical categories of the ACARP industry committees, underground, open cut, coal preparation, coal utilisation and greenhouse gas mitigation. However, the main difficulty arises because of the multi component content of many projects.

For example many (and perhaps the majority of) projects aimed at improving the application of technology towards solving a safety issue or production activity will potentially improve both because of the interrelationship of the two. Notwithstanding this difficulty it is estimated that approximately 25% of ACARP direct funding has had an occupational health and safety objective/impact. A brief overview of some ACARP projects is provided as an example with reference to this issue.

The key to successful underground safety and productivity is the measurement and management of both the geotechnical conditions and, increasingly, gas. Strata control and gas management forms a significant component of the underground portfolio of ACARP projects.

Strata Control

Underground coal mining is an operation involving bulk materials extraction and handling, with the resulting rapid development of large voids that are designed to collapse. The stress regime is quite different from most hard rock operations in that mine management must control strata above locations that are continuously changing/moving and responding to the significant stress changes caused by the mining of the targeted coal section of the strata. This means that they have to achieve maximum control of softer material for a minimum cost, which is certainly quite a challenge.

Project C11028 Self-Drilling Rock Bolt Technology - The automatic installation of rock bolts will improve operator safety and increase productivity. This project is assisting to develop a technique that is utilising an innovative self drilling bolt. A drill equipment manufacturer and a bolt manufacturer are working together with the researchers, Ground Support Services and CSIRO, to refine a prototype bolting system that is set to revolutionise future bolting operations and eliminate the source of many lost time injuries.

Project C11056 Geophysical Assessment of Fracture Grouting - The Oaky Creek Coal Mine is working with CSIRO to quantify the effectiveness of pre-grouting existing fracture zones in an attempt to improve the safe and efficient mining of coal that lies within this area. Again safety is a key driver of this important field of investigation, which, if successful, could lead to increasing levels of production when confronting difficult ground conditions.

Gas Management

The challenge is firstly to know where gas is located, the quantity present, how it will respond to drainage strategies, the rate of gas make during production and resultant operator exposure.

Outburst events are known to be associated with geological structure. ACARP projects C11038 Integration of Seismic Data for Mine Planning - being undertaken by CSIRO, and C10020 Investigation of Converted Wave Coal Seismic Reflection Data - by Velseis Pty Ltd are typical of the work being undertaken to advance the use of geophysical techniques for locating such structure. ACARP's investment in translating the techniques originally developed for the petroleum industry for coal exploration has led to Australia leading in the use of coal geophysics. 3D geophysical mapping is now a standard process in the Bowen Basin. Six years ago the geologists employed a grid of exploration boreholes to delineate a coal reserve, with anomalies being checked by seismic. Today 3D seismic is routinely used first, with drilling then employed selectively to resolve anomalies. The better definition of geological structure is producing safer more productive operations.

Contained gas is currently used as the parameter for determining the propensity of specific coal to outburst. The techniques employed to drain this gas are challenging and necessarily vary with the different seam characteristics.

Project C10012 Coordination of In-Seam Drilling and Gas/Outburst Research - John Hanes, coordinates a number of workshops across the Queensland and New South Wales underground operations where those responsible for drainage, including the drillers, mining engineers, geologists and researchers report on recent experiences. This sharing of industry experience is a key to ACARP successfully advancing the state of knowledge in such a critical safety area.

Project C10017 Optimisation of Goaf Gas Drainage & Control Systems - Dr Rao Baluso, CSIRO Exploration and Mining, has successfully modelled the flow of gas through goafs and into workings. His modelling work provides management with a reliable tool to assist them contain and control gas.

Project C11030 Variability of Coal Seam Parameters as they Impact on Outbursts - CSIRO, has quantified all the parameters that can contribute to an outburst event. In doing so they are working toward a more accurate assessment of outburst potential beyond the simple and possibly over conservative use of only gas contained.

The Challenge

Most of the effort has been directed towards the safety component of occupational health and safety. This has probably arisen for a number of reasons including:

- Operational/technical people can better identify with the more applied sciences than the so called "soft sciences" usually associated with occupational health issues
- Until fairly recently there was a hesitancy to delve into issues that may have an industrial relations connotation, and
- Other organisations, either associated with the coal industry (e.g. the former Joint Coal Board) or with industry generally, were addressing such issues on a wider front.

When I first gained employment in the Australian coal industry almost fifty years ago the importance of safety was recognised, but at a very much lower level than today. This was evident in the level of training given to new employees (or lack thereof), the attention to protective clothing, pre-employment and periodic medical examination and, essentially, a reliance on an understanding of compliance with mining legislation.

There is no doubt that the technological features associated with mine safety have advanced enormously and that the appreciation of wider safety issues and attention to training are well beyond that era, and much more aligned to present day expectations. There is also clear evidence of improved results. While it may not be relevant to draw on statistics from the mid 1950s, for a number of reasons including different circumstances/bases adopted over the period, even more recent comparisons demonstrate that advances have been made.

The average lost time injury frequency rate (number of lost time injuries per million hours worked) for the black coal industry in Australia contributing to and covered by ACARP (operating in the four states of Queensland, New South Wales, Western Australia and Tasmania) has shown the following trend in the last ten years of available information.

Lost Time Injury Frequency Rate, Black Coal Industry

State	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02
QLD	40	34	31	26	24	16	13	12	11	8
NSW	78	68	73	56	48	52	39	34	33	27
WA	130	78	91	61	41	32	29	16	28	17
TAS	37	10	29	30	19	14	0	7	35	20

The above information requires a number of observations, including the size and nature of the operations contained in each state total, to provide the basis for a full appreciation, but it is fairly clear that there has been a trend moving in the right direction.

While the same state based information is not at hand for duration rate (average lost time for every lost time injury) and severity rate (average number of days lost per million hours worked) it seems that the trend with respect to these two measures for the coal industry in total in Australia (which includes Victorian and South Australian operations) has been if anything worsening, in the case of severity rate in particular, or fairly static. The information on fatal injury frequency rate, while varying widely from year to year in relative terms, has not shown a substantially favourable trend.

Comparisons with overseas coal industries show that Australia is ahead of others in many respects. The conclusion from any objective analysis though is that we have no basis for complacency. In reality it could be argued that we have travelled the relatively easy distance towards what has to be the ultimate goal, however that is defined.

A New Direction

The program continues to adapt to changing demands. It is interesting to note that the industry's determination to achieve zero fatalities has caused the technical committees to begin to appreciate the importance and value of sociological science.

Advancing technology can not, and will not, guarantee zero fatalities. The industry must understand and address such issues as fatigue, training and propensity to undertake risks if this worthy goal is to be accomplished.

The approach to addressing issues utilising research disciplines in technical areas has been clearly evident within ACARP and this has been extended to a lot of safety issues, largely because of the clear association with production activities that needed a technical approach. There is still evidence of a reluctance to embrace the more occupational health and sociological aspects of the safety equation in the same approach.

Recent experience within ACARP would indicate that the chances of a "softer science" proposal being finally approved is probably less than half that of the rest.

Understanding that there is an application for this science to safety is not such a large step for the industry to take as it is already seeing how this work can help achieve a sustainable coal mining industry on other issues. The industry recognises the imperative of community, environment and profitability. ACARP technical committees have currently evaluated 9 proposals with titles such as:

- Mining Future in the Bowen Basin: Criteria for positive Communication and Decision Making
- Coal Mining Dependant Communities in Central Queensland: Industry/Community Engagement Strategies.

Just as technology cannot ensure a happy and mutually beneficial relationship with neighbouring communities and the regulatory bodies, technology alone will not solve all the safety issues.

Conclusion

Safety will always be a key component of the ACARP program. The way we go about solving the problems is quite obviously changing. Research is not, as the cynics would have us believe, the constant rework of old solutions. As mines get deeper and the resources become more difficult to mine safely and efficiently ACARP will continue to provide a base from which industry can confront difficult and demanding problems both technically and sociologically.

If we are to continue to make substantial gains in moving towards our ultimate goals in occupational health and safety we will surely need to apply proven research disciplines in new areas to assist. Technology and its advance will continue to provide part of the solution by access to improved machines, electronics controls, processes, etc., but the users of the technology are far more complex. The final steps will require an expanded approach to our research effort compared with the past. These will include application of disciplines not effectively used to date.

ACARP is a powerful facility. It is owned and directed by the Australian black coal industry. It has available to it valuable human resource skills, considerable financial leverage and access to excellent research competencies. The challenge is to gain maximum value from the opportunities available through its strengths.

Counting the Cost of Injury & Poor Health - An Analysis of QCOS Data

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Abstract

The Queensland Coal and Oil Shale (QCOS) Mining Industry Superannuation Fund provides the industry superannuation service. QCOS pay out superannuation benefits to the families of deceased members and makes insurance payments to persons with chronic disabling health conditions. The following analysis examines the QCOS death and total permanent disability data from 1998 to 2003 to provide the coal mining industry with a perspective on a previously unreported aspect of health and safety outcomes.

The proportions of persons who leave the industry with cancers, heart disease and traumatic injuries are discussed in the context of data on the general population for the equivalent age groups and the need to have health and safety management systems to manage health risks in the workplace.

Introduction

The complex interactions between workers and their workplace activities and environment, make it impossible to develop a single measure of health and safety performance. To assess the improvement in health and safety performance health and safety professionals review a number of indicators. Access to information on mine workers who have left the industry (including died) is limited by both organisational and privacy limitations. Two valuable sources of this information are QCOS and the National Deaths Index held by the Australian Institute of Health and Welfare (AIHW). A research report by SIMTARS / JCB Health and Safety Trust on 2001 examined the AIHW data for heart disease (Bofinger and Ham, 2002a, 2002b).

As part of both the superannuation regulatory requirements and a life and total permanent disability insurance business, QCOS make payments to clients (or their families) on claims made due to total permanent disability or death. De-identified data compiled from these claims is the basis for the examination of a performance indicator that counts the cost of death and total permanent disability in the Queensland coal mining industry. The information derived from this analysis is placed in context with other sources of coal mining industry health and safety data.

Background on QCOS

QCOS is legislated under the *Coal and Oil Shale Mine Workers' Superannuation Act 1989* (with amendments to June 2000) as the coal mining industry's superannuation and long service leave entitlement provider. QCOS collects employer superannuation and long service leave contributions from coal producers and contractors servicing the mines on behalf of approximately 10,000 clients most of whom are paid under the Coal Industry Award. In 2002, QCOS reported that the total funds under management had grown to $ 909 million. Benefits paid by the fund for 2001/02 were $45.6 million for which 4% was for deaths and 8% for incapacity.

Sources of Data

For both the superannuation regulatory requirements and a life and total permanent disability insurance business, payments are made to clients (or their families) on claims made due to total permanent disability or death. As clients reach 60 years of age, they may access their superannuation as either a lump sum or as an annuity. All funds must be withdrawn in this fashion by the age of 65 years. No data is there therefore collected on persons over 65 years and limited data is collected on persons older than 60 years.

The data provided by QCOS included the age, experience, mine type and year of last work of the mine workers as well as whether the worker was still working in the coal industry

In order to put the QCOS data into context, it is compared with related data sets published by the Department of Natural Resources and Mines (2002) and data compiled on deaths of mine workers as part of a 'Heart Disease Risk Factor' research project undertaken by SIMTARS (Bofinger and Ham, 2002).

Method of Analysis

The 267 records provided by QCOS were classified into 10 categories and analysed by category type, year and length of experience. For the purpose of analysis, the QCOS data has been divided into groups consistent with the International Classification of Disease (ICD Version 10). For occupational risk assessment purposes, a modification is made to the classification system to capture information of deaths and total permanent disability due to nervous and mental disorders such as depression, suicide and alcoholism. Under the ICD, these may be classified as external injuries which is often the clinical outcome.

The age distribution of the coal mining industry employees was estimated from health assessment age distribution data published by the Department of Natural Resources and Mines (2002). Death rates by cause were estimated from the QCOS data and compared with general community (male) data published by the Australian Institute of Health and Welfare (2002).

A method of estimating the total cost to the community of death and total permanent disability was used to compare the QCOS data with costs estimated from other data sets published by the Department of Natural Resources and Mines (2002).

Results

The number of claims for total permanent disability (TPD) and death is provided in Table 1. The deaths show a highly irregular pattern that indicates that data from individual years is of limited use for statistical analysis. As the insurance started in 1997-98, data for 1998 should be considered as not representative of a normal full year. The delays in lodging and assessing claims cause to data for 2002 and 2003 to be considered incomplete.

Table 1: QCOS Data - Deaths and TPD by Year.

Year	Deaths	TPD	Total
1998	10	22	32
1999	8	65	73
2000	13	59	72
2001	6	46	52
2002	13	24	37
2003	1	0	1
Total	**51**	**216**	**267**

Table 2 shows deaths and TPD by age group. It should be noted that persons in the 30 to 45 age group dominate the workforce. The table shows most TPD and deaths are in the 45 to 60 age groups. The comparisons with the general population are examined in a later section.

Table 2: Deaths and TPD by age group.

Age Group	Deaths	TPD	Total
>25	1	3	4
25 - 29	4	6	10
30 - 34	6	7	13
35 - 39	6	21	27
40 -44	4	25	29
45 - 49	12	42	54
50 - 54	10	62	72
55 - 59	8	41	49
60 –62	nil	9	8
Total	**51**	**216**	**267**

The most common disorder is musculo-skeletal disorders as shown in Table 3. Other common causes include external causes (injury), cancer, circulatory disease (heart attack and stroke) and nerve and mental disorders. The average age of sufferers of external causes is 41, while circulatory disease is more likely to affect the oldest group at an average age of 53 years.

A total of 51 deaths were reported in the QCOS data. The common causes of death were cancer, external causes (injuries), circulatory disease and nervous / mental disorders. It should be noted that 1998 to 2002 has been a relatively good period with only 8 deaths reported by the Mines Inspectorate. This compares to 1994 when 11 deaths were reported largely as a result of the Moura Disaster.

Table 3: Death and TPD by cause.

Cause	Deaths	TPD	Totals	Av. Age
Cancer	14	20	34	51
Circulatory disease	12	21	33	53
Ear disorders	0	3	3	
Endocrine disorders	0	3	3	
Infectious diseases	0	5	5	
Musculo-skeletal disorders	0	83	83	47
Nervous / mental disorders	9	43	52	48
Respiratory disease	0	4	4	
External causes	13	32	45	41
Other	3	2	5	
Total	**51**	**216**	**267**	**48**

Table 4 shows that external causes dropped dramatically in 2001. This coincided with the introduction of the new legislation and increased drug and alcohol screening. There appears to be a decline in circulatory disease but a possible increase in nervous / mental disorders which is also reflected in other injury and workers compensation statistics. The 2002 data is incomplete because of time delays in lodging and processing claims.

Table 4: Causes by year.

Cause	Year					Totals
	98	99	00	01	02	
Cancer	5	7	7	7	8	34
Circulatory disease	7	10	7	3	5	32
Musculo-skeletal disorders	8	21	26	21	8	84
Nervous/mental disorders	3	11	12	14	11	51
External causes	7	13	16	5	4	45
All Others	2	11	4	2	1	20
Totals	**32**	**73**	**72**	**52**	**37**	**266**

The Department of Natural Resources and Mines (2002) reports that underground miners represent 25% of the workforce but suffer over a third of QCOS reported disorders shown in Table 5. One measure of the effectiveness of safety training programs is the percentage of serious disorders that afflict workers with less than five years experience. Table 5 shown that 32% of underground disorders have serious conditions compared to only 13% for open disorders. Work by Ham (2000) showed that the open cut workforce is slightly older than the underground workforce.

Table 5: Distribution by Mine Type and Experience Group.

Mine Type	**Experience Group**		**Total**	% < 5 years
	0 to 5 years	5 plus years		
Open cut	22	144	166	13
Underground	28	59	87	32
Other	4	10	14	29
Total	**54**	**213**	**267**	**20**

Examining Table 6, there is a common trend in most disorders that the open cut mines show a concentration of the disorders in the 10 plus years experience group while disorders are more evenly spread among underground workers.

Table 6: Disorders by Mine Type and Experience Group.

Disorder	**Experience Group**	**Employer**			**Total**
		O / C	U / G	Other	
Cancer	0 - 5	6	4	1	11
	5 - 10	1	1	0	2
	10 plus	17	4	0	21
Subtotals		24	9	1	34
Circulatory disease	0 - 5	1	2	0	3
	5 - 10	2	3	1	6
	10 plus	17	4	2	23
Subtotals		20	9	3	32
Musculo-skeletal disorder	0 - 5	4	11	0	15
	5 - 10	6	6	1	13
	10 plus	38	16	2	56
Subtotals		48	33	3	84
Nervous disorder	0 - 5	3	3	1	7
	5 - 10	5	3	1	9
	10 plus	25	7	3	35
Subtotals		33	13	5	51
Traumatic Injuries	0 - 5	6	8	1	15
	5 - 10	5	6	0	11
	10 plus	13	5	1	19
Subtotals		24	19	2	45
Other	0 - 5	3	2	0	5
	5 - 10	2	1	0	3
	10 plus	10	3	0	13
Subtotals		15	6	0	21
Totals		**164**	**89**	**14**	**267**

As a means of putting the cost of death and total permanent disability in to a financial context, an estimate is made of lost earnings based on an estimated average $70,000 annual income (estimated from Joint Coal Board (2001) figures). Table 7 shows that while miners with less than 5 years experience made up 20 % of cases, their losses were 30% of the total of $215 million.

Table 7: Distribution of Earnings Lost by Mine Type and Experience Group.

Mine Type	**Experience Group**		**Total**
	0 to 5 years	5 plus years	
	$ M	$ M	$ M
Open cut	32.8	91.4	124.2
Underground	37.8	53	90.8
Total	**70.6**	**144.4**	**215**

Comparison with Other Injury Data Sets

A comparison with between NRM injury and lost time data, Workcover data (NRM, 2002) and lost wage estimates (annualised) based on QCOS death and TPD data is shown in Table 8. The data is reduced to man-years lost and wage costs for comparative purposes.

Table 8: NRM injury and lost time data, Workcover data compared to QCOS data.

Data Source	**Days lost**	**Man-Years lost**	**Total Cost $M**
Reported Lost Time Injury Data	3627	18	1
Injury Lost Time from Production Returns	5475	27	2
Sickness Lost Time from Production Returns	31158	156	12
Workers Compensation Report			4
Lost Wage Estimate from QCOS data		660	43

In 2001, the Australian Institute of Health and Welfare supplied data on deaths from a register of Queensland and New South Wales coal mine workers for a research project. Some of this data was published in the SIMTARS/JCB Health and Safety Trust Heart Disease Risk Factor Research Report. The published data on 292 former Queensland mine workers is compared to the QCOS data on Table 9. The data sets are similar in percentage terms for circulatory disease and external causes. Cancers appear less in the QCOS data. The SIMTARS/JCB Project data did not report deaths related to nervous / mental disorders separately. The data is probably hidden in with other causes of death. The QCOS data confirmed the findings of the SIMTARS/JCB study that miners had a lower circulatory disease risk than the general population.

Table 9: QCOS Data compared to SIMTARS/JCB Heart Disease Risk Research Project.

Cause of Death	**QCOS Data**		**SIMTARS/JCB Project Data**		**AIHW Gen.Pop.**
	No.	%	No.	%	%
Cancer	14	27	113	39	27
Circulatory disease	12	24	75	26	40
Nervous/mental disorders	9	18	0	0	na
Respiratory diseases	0	0	12	4	10
External causes	13	25	66	23	6
Other	3	6	26	9	17
Total	**51**	**100**	**292**	**100**	**100**

In *Australia's Health 2001*, the AIHW published information on deaths for various age groups due to various causes. Two of the age groups reported (25 to 44 and 45 to 64) largely fall within the groups of the QCOS data. After estimating the age distribution of the coal mining population from reported health assessment data (NRM 2002), it was possible to compare the QCOS data (1998 to 2002) and the AIHW data (2000) in terms of death rates per 100,00 employees. This is shown in Table 10.

While some caution needs to be exercised in interpreting the relatively low number of QCOS reported deaths, the coal miners generally have statistically significant (95% confidence) lower death rates than the general population. There are two important exceptions to the general trend. Firstly, there is a higher rate of cancers in the younger mining work group but with the small numbers involved the difference is not statistically significant.. This issue warrants further research. The second issues is that the AIHW did not report death due to nervous / mental disorders. The QCOS data demonstrates that focus on long-term nerve disorder and stress risk management is warranted.

Table 10: Estimation and comparison of death rate between QCOS and AIHW data.

At the other end of the health and safety spectrum, Kerr (1966) re reported that for each industrial fatality reported there were between 3 to 5 occupational related fatalities that were not reported but surfaced on coroners reports and death certificates as likely to be of an occupational origin.

The Industry Commission report on '*Work, Health and Safety*' (1995), accepted evidence being compiled for the Worksafe Report on Best Estimate of the Magnitude of Health Effects of Occupational Exposure to Hazardous Substances (Kerr, 1996) that identified widespread under-reporting of occupational related death through illness. The Commission concluded that systems needed to be put in place to monitor long term exposures and provide a mechanism for collating long term health outcomes for persons working in environments of elevated risk.

The mining industry collects some exposure data while the doctors collect health data and QCOS captures some critical health outcome data. There is a need for a collective effort to compile these data sets for dose-response risk management studies without jeopardising the privacy entitlements of individual mine workers (Bofinger and Ham, 2001)

Population Analysis of Group Aged 25 to 44

	General population			**Mining Population**			**Mining/Gen Pop Rate %**
Disease	Numbers Gen.Pop	Percent	Rate/ 100,000	Numbers Min.Pop	Percent	Rate/ 100,000	
Cancer	228	5.3	7.78	4	19.0	13.38	172
Circulatory Disease	565	13.1	19.22	1	4.8	3.34	17
Digestive Disorders	328	7.6	11.15	0	0.0	0.00	0
Injury	2233	51.8	76.01	10	47.6	33.44	44
Nerves/Mental	na	na	Na	5	23.8	16.72	na
Other	957	22.2	32.58	2	9.5	6.69	21
Total	**4311**	**100**	**146.74**	**21**	**100.0**	**70.23**	**48**

Population Analysis of Group Aged 45 to 64

Disease							
Cancer	4626	41.4	206.33	10	33.3	44.25	21
Circulatory Disease	3184	28.5	142.04	10	33.3	44.25	31
Respiratory Disorders	536	4.8	23.92	0	0.0	0.00	0
Injury	1061	9.5	47.35	3	10.0	13.27	28
Nerves/Mental	na	na	Na	4	13.3	17.70	na
other	1765	15.8	78.74	3	10.0	13.27	17
Total	**11173**	**100**	**498.38**	**30**	**100**	**132.74**	**27**

Discussion

McDonald (1995) criticised the coal mining industry for over-emphasis on lost time injury rate as a primary indicator of heath and safety performance. His concern was that focus on lost time injury frequency rates deflected focus from the causes of serious injuries that constituted 15% of injuries but represented 85% of injury costs.

The QCOS data set has been very useful but it is limited in that death and disability data of persons over 60 years age is not reliably collected. To obtain a more complete picture, data needs to be regularly sourced and analysed form the Deaths Index held by the AIHW.

The delay in reporting the QCOS data needs to be considered in drawing conclusions from the results. The assessment of total permanent disability often takes 6 to 12 months to assess while a few cases may take several years. By late June only one case had been reported for the 2003 year. In first six months of 2003, 9 cases for 2002 were reported and a further six came from 1999 to 2001. The delay in reporting may be incorrectly interpreted as declining rates of death and total permanent disability. The drop from 72 in 2000 to 52 in 2001 should be considered as real, but the drop to 36 in 2002 should not be take as a reliable indicator as more total permanent disabilities can be expected to be reported for 2002 in the future.

As the insurance program only began in 1997-98, the 1998 data set should be regarded as underestimating the real extent of total permanent disabilities.

From a legislative perspective, section 6 of the *Coal Mining Safety and Health Act 1999* states that the objective of the act is to protect the health and safety of persons at coal mines to be protected and ensure that the risk of injury or illness ... be at an acceptable level'. While current systems that include safety management plans deal effectively with the management of short term risks, the management of long term risks require an entirely different approach.

Before the risks can be effectively managed and demonstrated to be managed, it is necessary to establish an effective data collection system. Division 2, Part 6 of the *Coal Mining Safety and Health Regulations 2001* (Coal Mine Workers Health Scheme) sets out a framework for the collection of long term health and exposure monitoring. Importantly, sections 49 and 53 require a safety management plan for monitoring of workers exposure to hazards with (presumably reliable) data to be maintained for 30 years. The question of why should the data be kept for 30 years needs to be considered. From an evidence based risk management perspective, the data has little meaning if it can not be used to correlate cumulative exposure with the progression of degenerative health outcomes.

One of the limitations of the regulation is that it is difficult to systematically capture final health outcome data – either of death or total permanent disability. This is where the QCOS data on death and total permanent disability is particularly valuable. While it may be possible to extract largely the same data from the Workcover and Australian Institute of Health and Welfare databases the process would be complex, less reliable and would have a time lag.

As a part of employers' obligations to have safety management plans, there is a need to access reliable evidence based risk assessments so that appropriate trigger levels for management of persons at risk can be set. As outlined above, the legislation sets out a frame work to collect the necessary data for the evidence based research necessary to assess critical points of increasing risk. While technically it is feasible to obtain the exposure and health outcome data, there is also the issue of confidentiality of private health data. Ethics considerations demand workers to sign consent forms for researchers to gain access to medical records and health outcome data that need to be analysed in conjunction with the exposure data.

Conclusions

A mechanism to use superannuation fund data to identify some adverse long-term health outcomes has been demonstrated. The data has been analysed and placed into the context of related data sources. Musculo-skeletal disorders are the most common cause of total permanent disability (83 of 267), but are not identified as a cause of death. Nervous and mental disorders (52) are the second highest cause of death and total permanent disability and represent the most common (14) cause of death. External causes (45) is the third most common issue reported in the QCOS data. Other common causes of death are cancer (14 deaths) and circulatory disease (12 deaths).

External cause injuries afflict younger persons where the average age is 41 years. By comparison, circulatory diseases are likely in an older group where the average age is 53 years.

Underground coal mines constitute 25% of the workforce but suffer 30% of QCOS reported disorders. With the open cut mines, the disorders are more focussed on the older/more experienced groups.

If the annual cost of injury is only counted in terms of days lost from reported injury data, the estimated cost is only $1M, but Workcover statistics indicate a cost of $4M. This compares with data from lost time returns indicating sickness may cost $12M per year. These statistics generally exclude QCOS reported death and disability that is costing the individual mine workers and community approximately $43M per year.

Combining QCOS data and reported health assessment data, it has been possible to estimate death rates for various disorders for mine workers in the 25 to 44 and 45 to 65 age groups. Comparing the results to those published for the general Australian population data, death are generally lower in the coal mining industry. While cancer appears more common in the younger age group, small numbers prevent this from being a statistically significant difference.

The reporting structure for the general community does not recognise nervous / mental disorders in the same way as classified in the QCOS data which identifies it as a major issue. This concern is supported by data from the Inspectorate and Workcover that identifies stress as a major growth area in both mining and general population occupational disorders.

The classification of cause of death or total permanent not always clear cut. Some cases have multiple causes in which the key issues is a matter of personal judgement. There is almost a continuum between back disorders, back pain, pain, depression, alcoholism and suicide. Again classification may be subjective. While the classification has largely followed the International Classification of Diseases, a departure has been made for risk management purposes for nervous and mental disorders. This group includes suicide and alcoholism as well as depression and pain.

The most ambiguous issue is back pain. Many people in the industry have a level of back pain. The majority is believed to be associated with a degeneration of the bones and cartilage in the spine that impinges on nerves within the spine. The ambiguity lies in the question is this a nerve or musculo-skeletal disorder. The approach taken in this paper is to classify it as a nerve disorder unless there is some additional reference to the musculo-skeletal system or traumatic injury.

The QCOS data set only commenced in 1998 and is limited in that death and disability data of persons over 60 years age is not reliably collected. To obtain a more complete picture, data needs to be regularly sourced and analysed from the Deaths Index held by the AIHW. This data set overcomes the problem associated with interstate migration.

This analysis has provided an industry wide perspective. As a part of the legislated obligation, mine operators are required to have a Safety Management Plans to manage risks associated with hazardous exposures. There is a need to incorporate exposure data with this style of data collection and analysis at the industry and corporate levels to demonstrate that long term work conditions and environments are being effectively managed and not causing unacceptable risks. This is, however, a new challenge.

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What Works Best at Improving Mine Worker Safety & Why Does it Work

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Abstract

This paper reports on the results of an ACARP funded project that investigated the effectiveness of safety programs at coal mines by determining the factors that lead to success.

There were two parts to the project. One investigated the strategies used throughout the industry to plan and implement safety programs. As part of the definition of what is happening industry-wide, a questionnaire investigating programs at all levels from individual to corporate was distributed. To compensate for the low response rate to the questionnaire, the conference proceedings for New South Wales and Queensland for the past five years were scanned. This information was combined with the results of the survey to give a reasonable picture of what was happening in the industry.

The second part considered five different programs in place at minesites. Investigations and evaluations on individual projects were undertaken at mines in Queensland and New South Wales. These programs include training, health interventions, audit, risk assessment and behavioural and attitudinal change and cover basic safety programs through to fitness for duty programs. The programs were analysed using a program evaluation model.

The factors identified as the three most important for success were the identification of the need for the program, actual and perceived commitment by management and allocation of adequate resources.

Introduction

How do we know if a safety program is working? Traditionally, the coal industry has tended to look at the downstream outcomes of safety programs such as accident statistics to ascertain the success or failure of a safety initiative. The limitations of these statistics as measures of program effectiveness are recognised, however, such injury statistics and compensation data may be of benefit in prioritising workplace intervention strategies. When it comes to safety, the mining industry is not plagued by new injuries, but rather finding effective solutions to existing problems.

Program Drivers & Motivators

Understanding what drives a program is one of the most important factors when determining a successful outcome. Drivers assist in shaping a program's goals and objectives. At least five factors may motivate the decision to implement programs to address safety issues and these have been identified in one form or other as the drivers of safety programs. These five include:

1. Employer's enlightened self-interest
2. Information on hazards and controls
3. Injury costs and workers compensation
4. Worker or Union pressure
5. Legislation and Regulation.

Additionally we are now seeing an increasing awareness of tort liability due to the growth in the number of cases involving litigation for injury and associated large payouts.

Once the drivers have been identified, it is important to identify both intrinsic and extrinsic motivating factors. Four types of factors have been identified as determinants of workers' safety motivation:

- Safety climate of an organisation - safety climate refers to workers' interpretations of features, events and processes in the work environment that are relevant to their safety
- Task feedback - the rarity and delay of adverse effects from single tasks can lead workers to engage in increasingly unsafe acts as workers develop a sense of "unrealistic optimism" based on experience of innocuous outcomes of unsafe acts
- Workgroup norms - these norms are informal rules the groups adopt to regulate and regularise group members behaviour. Workgroup norms are most likely to have reached a high degree of consensus and intensity when there are common goals and interdependent within the team
- Organisational control systems – formal processes by which the organisation directs the members to action and monitors behaviour and results to ensure organisational goals are accomplished.

Evaluation Techniques

To effectively assess the success of a safety program, the evaluation must match the objectives of the program being evaluated. The reasons why safety programs are evaluated fall under two broad categories:

1. to demonstrate accomplishment of proposed objectives
2. to guide internal program decision-making.

The two categories of evaluation differ markedly. The first is usually called for by a source external to a program. The second is performed by a program manager to enable the best use of resources etc to accomplish the proposed objectives. The first is historical (How well did I do?), the second current (How am I doing?).

Impact evaluation is a third general type that seeks to determine the effects of the program.

No matter what the reason for being undertaken, the evaluation needs to consider a range of perspectives including the organisational and the worker perspective.

This research project was designed to provide a framework for the evaluation of the effectiveness, efficiency and appropriateness of safety programs and initiatives at all levels in the coal mining industry and to identify the key factors affecting the success of programs. This project was funded by the Australian Coal Association Research Program (ACARP) with additional co-operation and in-kind support from mines in New South Wales and Queensland and Simtars and MISHC.

Project Work Program

The project was conducted in three stages. In part 1, the key strategies currently in use in the industry were investigated and defined by using a survey to identify the drivers, complexity, regulatory requirements, type of program, and use of incentives. Additional information was included from recent Queensland and New South Wales mining health and safety conferences. This information was used to set the safety programs investigated in part 2 in the industry context.

Part 2 of the project assessed selected safety programs and strategies at a site specific level. Assessments were undertaken at five sites and covered a range of programs. The evaluations followed the model for evaluation proposed for the project (Figure 1) and covered both programs already in place and programs about to be implemented.

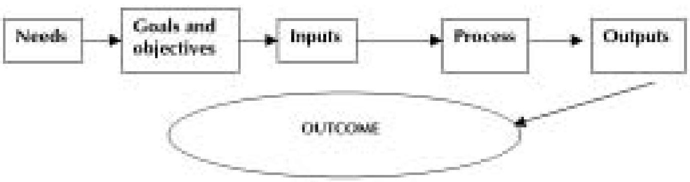

Figure 1: Model for evaluation of safety programs.

The following programs were included in the project.

1. Fatigue Management Training Program

This was a training program designed to promote self awareness and management of factors that could lead to fatigue at a mine site. It involved face to face training sessions that ran for approximately 60 minutes. These were provided by well qualified external providers. Additional reference materials were supplied for participants to take home.

2. Perform: Manual Tasks Project

This project examined the effectiveness of an industry wide, rather than workplace specific, approach to the prevention of manual tasks injuries. The aim was to generate potential solutions to common high risk manual tasks in the open cut coal mining industry through the results of manual task risk assessments and control measures suggested by staff participating in Perform training sessions. These solutions were then implemented and their effectiveness assessed.

3. Safety Audit Observation Program

This program introduced safety act observations (SAO) as a method of identifying unsafe acts and conditions at the mine site. The purpose of the safety observations was to improve the safety and welfare of all people who work and visit a site.

4. Risk Assessment

The project was the completion of a risk assessment to evaluate the risks associated with fatigue on site and to identify control options. The risk assessment was part of a larger project to address fatigue on site.

5. Positive Action Safety System (PASS)

This program was a safety management system called Positive Attitude Safety System (PASS). PASS was introduced to improve safety communications between workers and management. This system was both a top down/bottom up approach that requires individuals to identify and control safety issues at site level. It was introduced using a training program for both management and workers.

In part 3, these results were used to identify the key components of safety programs that lead to success. The measures of the success of the safety strategies were considered in terms of

- Effectiveness of health and safety outcomes, eg:
  - reduction in injury, disability, stress or hazard exposure
  - increase in knowledge
  - change in behaviour or attitudes.

- Economic outcomes and return on investment, eg:
  - the effect of the program on productivity, employee turnover, equipment, or costs.

The original intent of the project was to assess the economic outcomes in terms of the following formula.

$$\text{Cost}_{\text{problem}} \infty \text{Cost}_{\text{cost of solution}}$$

$$\text{Cost}_{\text{cost of solution}} = \text{Cost}_{\text{safety program}} \times 100/\% \text{ effectiveness}$$

These formula suggest that the cost of a safety program must be less than the cost of the problem it is intended to address taking into account the program effectiveness. No program is 100% effective and it is generally recognised that different types of programs have different levels of effectiveness.

This could allow an analysis of the allocation of resources and return on investment in terms of seriousness of the problem and effectiveness of solutions.

Results

Part 1: Strategies Currently Used

Given the limitations of the data available for assessment, the results of the questionnaire and the analysis of the conference proceedings provided some reasonable insight into the key strategies currently being used by the industry.

There was greater emphasis on individual and work environment programs than on organisational programs (Figure 2). These programs were generally driven from a management level (Figure 3). These management driven programs were more likely to have been the result of a needs assessment than worker driven programs ie a need was identified and management drove a program to address that need.

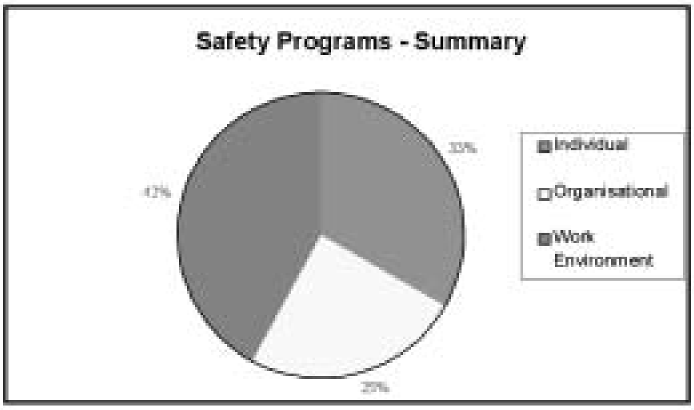

Figure 2

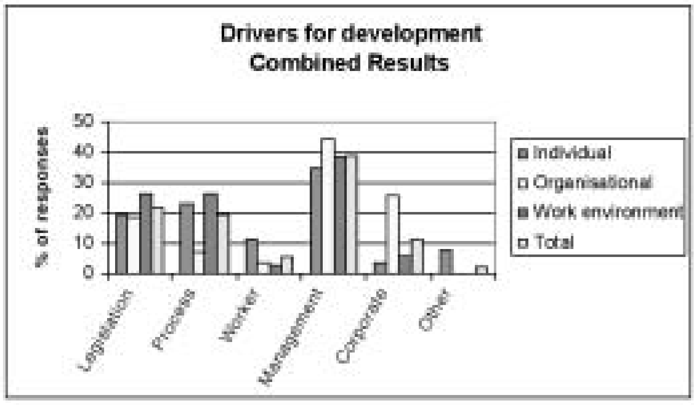

Figure 3

The literature reports on the need for management to make a commitment to the longevity of safety program. The programs reported indicated a relatively short time frame of less than 12 months for most projects. 24% of programs were reported as being implemented over greater than 12 months This may have been because most programs reported were only initiated less than 12 months prior to reporting and were still active programs for a longer period of time.

The most important resource issue reported was rostering with the associated difficulties of the availability of personnel. Physical resources were not reported to be an issue and that indicates a level of commitment by the management and organisation to the programs.

The combined questionnaire and proceedings results showed that approximately 80% of the programs had been assessed and also that approximately 90% of the programs had meet objectives (Figures 4 and 5).

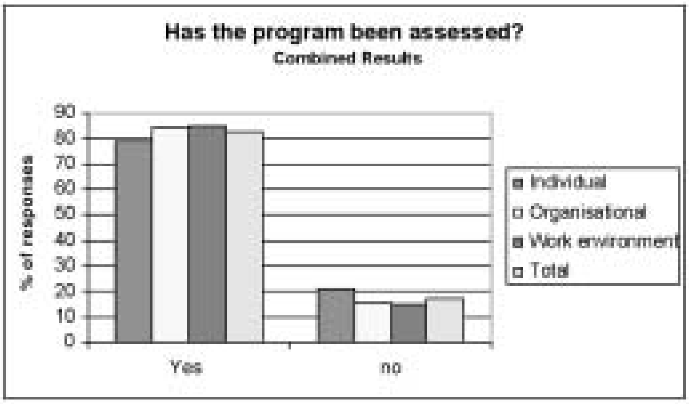

Figure 4

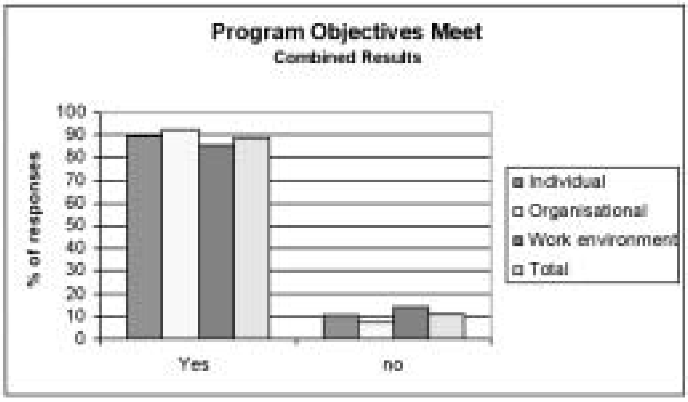

Figure 5

For the organisational programs reported as having met objectives, 92% had been assessed and for the successful work environment programs, 83% had been assessed.

Part 2: Mine Site Safety Programs

This part of the project involved the evaluation of five different safety programs at five sites. The five programs were:

i. Fatigue management training program
ii. Perform: Back care project
iii. Safety Audit Observation Program (SAO)
iv. Risk Assessment
v. Positive Action Safety System (PASS).

Evaluation Methodology

The evaluation methodology was based on the model shown in Figure 1. The terms used in the model are defined below and were based on Harrison (1999) and Robson et al (2001).

Needs:
Predisposing factors or the identification of risk of injury, groups or individuals exposed to some risk, or the deficiency of information and/or lack of intervention to address an injury risk. This is sometimes seen as absolute need eg legislative requirements, but more often as a relative need eg excessive risk. This determines what type of program is needed.

Goals/objectives:
A key link with strategic planning as a statement of intended outcome eg reduction in injury rate by 10%. This is the basis for identification and assessment of effectiveness.

Inputs:
The financial, physical and human resources that are allocated and consumed to enable a program to operate eg the funds allocated to purchase equipment or train users.

Processes:
The operations of the program being evaluated eg participation in training. This evaluation can be used to determine if the program was implemented as planned and assess the quality of the delivery of the program.

Outputs:
The products or immediate results created by the intervention or program.

Outcomes:
The consequences for the stakeholders of the process and/or its outputs. The outcomes may not necessarily be the impact of the outputs.

The evaluation process covered each of these areas and included:

- A series of questions completed by the site program co-ordinator
- Observations by the project personnel of the programs in operation
- Questionnaires and interviews with workers participating in the project
- Analysis of data collected for the project (where available).

The evaluation consisted of the following criteria.

Effectiveness	as indicated by the extent that the outcomes achieve the objectives. It shows the relationship between the outcomes for the intended recipients and the objectives for the project. It is ***"doing the right thing"***.
Efficiency	as indicated by the amount of outputs for the given inputs. This is an important type of indicator in terms of accountability for the resources used and productivity. It is ***"doing it for the right cost"***.
Appropriateness	identifies the relevance of the objectives to participants needs eg a program requiring heavy personal protective gear may be efficient and effective but may be inappropriate due to the hot physical environment. It is ***"doing it right"***.

Effectiveness & Appropriateness

The programs evaluated have been assigned a percent effectiveness based on the information provided by the sites and the experience of the research personnel during the evaluation exercises.

The results are based on an estimate of how well the objectives were defined and whether the programs met the objectives. The simpler the objectives, the easier to estimate effectiveness eg the risk assessment had a straightforward objective; the SAO program was more complex in what it was trying to achieve. The results of questionnaires and interviews are the basis for the attributed effectiveness. This remains a somewhat subjective estimate and the results are open to discussion.

Efficiency Based on Economic Estimates

In order to evaluate the economic efficiency of the safety programs studied, a number of estimates were made.

A single lost time injury was allocated a direct insured cost of $4000. This is an average cost based on the data supplied in the Queensland Mines and Quarries Safety Performance and Health Report, 2001 (Department of Natural Resources and Mines, 2001) and the costings estimated for Queensland and New South Wales by Culvenor et al (2000).

Work completed by Esson (1992), estimated the indirect or uninsured costs associated with an accident or injury for the open-cut coal mining industry to be 9 times the insured costs. This is considerably higher than estimates for other industries that vary between 1 and 4 times and takes in to account lost productivity. This means the total cost of a single lost time injury could vary between $4 000 and $40 000.

Musculoskeletal injuries (sprains and strains) represent more than half of all compensation claims in coal mining involving five or more lost days. NOHSC has determined that sprain/strains involving more than 5 days lost work for the Australian coal industry averaged 810 per year for the four years 1996/7 to 1998/9 (http://nohsc.info.au.com/).

While national claims cost data is not available, Qstats has estimated the average cost of similar claims in Queensland in 99/00 was $22,486. This equates to a daily direct costs of $4000. This is consistent with the direct costs estimated for other injuries in this project.

Mabbott et al (1999) estimated the cost of a fatigue related injury to be $40 300. This took into account direct and indirect costs of injuries excluding equipment damage.

The Occupational Safety and Health Administration (OSHA) in the United States reports that the ratio of indirect to direct costs varies from a high of 20:1 to a low of 1:1. The lower the direct costs of an accident, the higher the ratio of indirect to direct costs. OSHA generally uses a ratio of 4.5 (OSHA, 2002).

Given the range of these estimates, the OSHA value is used in this project. Using this value, $22 000 was chosen as the total direct and indirect cost to be assigned to a lost time injury for the estimate of the economic value of the programs considered.

Table 5.1: Costs and effectiveness of safety programs.

Program	**% effectiveness**	**Cost of safety program**		**Cost of solution**	
		Implementation	**On-going per year**	**Implementation**	**On-going per year**
PASS	70	18 500	26 000	26 428	37 142
SAO	70	10 350	5 400	14 857	7 714
Risk Assessment	80	22 500		28 125	
Fatigue training					
• Legislative obj	95	40 000	10 000	42 105	10 526
• Informed Workforce	<50	40 000	10 000	>80 000	>20 000

Given this averaged data, the costs of the solutions for the programs evaluated indicate that there is an economic return for the programs if they prevent more than one injury. This is consistent even for the fatigue training program that was of limited effectiveness.

Project Outcomes

The results of the analysis of the strategies and factors associated with safety programs at an industry level were consistent with the factors identified in the individual mine site programs evaluated. The model proposed for use in evaluating the programs was effective in identifying the strengths and weaknesses of the programs.

The factors affecting the success of safety programs are complex and inter-related. It is not possible to identify a single factor that guarantees success. A model was developed to demonstrate the relationship between these factors. At the simplest level, the three major factors leading to success were identified as:

- The clear identification of the need and objectives for the program
- Actual and perceived commitment by management
- Allocation of adequate resources, including timeframe.

The impact of management commitment greatly influences the perceptions and impacts of the programs on individuals. These in turn affect the safety behaviours in the workplace. There are intrinsic and extrinsic motivators that must be consistent with the program to allow continued success. These motivators are also influenced by management commitment and a number of environmental, organisational and individual factors.

The results of this project allowed the development of "Steps to a successful safety programs". This guide identifies the basic steps that need to be considered for the development, implementation and success of safety programs for the coal mining industry.

The guide suggests that programs are considered under the following headings.

Steps to a Successful Safety Program

Step 1 – Determine the Need

The identification of why a safety program is needed acts as the first step in the process.

If more than one need is identified, it is important to consider if these needs can be met by a single program or if there are conflicts.

An estimate of the costs of the problem should also be established. Costs should include direct and indirect costs eg:

- Accident and injury costs
- Lost time costs
- Investigation costs
- Equipment damage and repair costs
- Productivity losses
- Possible costs to reputation.

This allows a program appropriately costed to meet the problem to be devised.

Step 2 – Identify the Main Driver

Program drivers assist in shaping a program's goals and objectives and are important in providing both intrinsic and extrinsic motivation for program success. These drivers may change throughout the life of the program depending on the nature of the program eg a management introduced program being "owned" by workers. If such changes to drivers are anticipated, they need to be clearly identified at the introduction of the program.

Step 3 – Goals & Objectives

The goals and objectives of the safety program need to be defined and reflect the identified program needs before the program is developed. The outcomes of the program need to reflect the goals and objectives.

The strategies to achieve the objectives need clarification as to whether they are based on:

- Knowledge, attitude or behavioural change
- Environmental change
- Technical/equipment change.

These objectives need to be achievable and, where possible, measurable.

The stakeholders and target audience for the program also needs to be clearly defined at this stage.

Step 4 - Implementation of Program

(a) Timeframe

The timeframe of the project should be defined as part of the initial process.

(b) Identification and Allocation of Resources

The allocation of resources needs careful consideration if the goals and objectives are to be met. Resources need to be appropriate and adequate.

Resources fall under the following categories:

• Physical resources	eg equipment, training materials
• Human resources	eg trainers, co-operation of supervisors and -management
• Financial resources	eg cost of time of program, effect on productivity.

(c) Costs Estimates

Estimating the costs of the program allows a comparison of the cost of the problem with the cost of the solution and fills a need for objective evidence to support claims of program cost effectiveness.

The programs costs need to include:

- Development costs;
- Implementation costs;
- On-going costs.

Step 5 – Evaluation

An evaluation of a safety program should consider the outputs and the outcomes of the program.

- The overall worth of the program in terms of effectiveness, efficiency and appropriateness.

A copy of the guide in included in the project report available from ACARP.

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Improving Significant Incident Management in Underground Coal Mines

Associate Professor David Cliff, University of Queensland

Abstract

This paper will outline the findings of the recently completed ACARP funded project looking at improving the investigation and management of significant incidents in underground coal mines particularly as they relate to fires or explosions. Many of the tools developed for this project could also be applied to metalliferous and open cut coal mines.

The genesis for this project was the author's experience in dealing with fires and explosions in underground coal mines over the past fourteen years and participation in the level one emergency response simulation exercises conducted in Queensland. The findings from these exercises, as they relate to incident management, formed the starting point for the project.

The project focussed on the development of computer based tools to assist in the identification and investigation of these incidents. The project has created a program based on a Microsoft Excel® spreadsheet for collecting and displaying mine environment information superimposed on a mine plan. Another Excel® based program developed by Dartbrook Colliery to track decisions and key events is also incorporated into the ACARP project. In addition e-book software has been used to translate mine procedures, advisory notes and trigger and action response plans into electronic documents for ready access on and off site. In addition Pocket computers have been utilised to increase flexibility, speed response and remove mounds of paper.

The paper will demonstrate prototype systems initially developed for the two mines that have participated in the project, Dartbrook and United Collieries.

None of the software developed is proprietary. It is all available either freely or at minimal cost. The host software is all widely available and generally a Microsoft product which most users would be familiar with.

Background

Significant Incidents & Studies

The author has been involved in investigating and assisting in the management significant incidents at a number of mines including Dartbrook Colliery (1997,1999, 2002), United Colliery (2001), Wallarah Colliery (2001), New Hope Colliery (1989, 1991), North Goonyella Colliery(1997, 1998), Moura No.2 Colliery (1994), Huntly West Colliery NZ (1992), and Ulan Colliery (1991) as well as analysis of older episodes at a wide range of mines stretching back into the 1960's. The majority of these incidents related to spontaneous combustion episodes. In addition more information was obtained during major studies of inertisation at Cook Colliery (1997) and goaf gas behaviour at Moranbah North (1999). The details of these events have all been published previously. The issues raised in these events are consistent with those coming from the level one exercises below. In general they relate to:

- Data acquisition, validation, reporting, and analysis
- Difficulty in visualising what is happening and therefore why it is happening
- Collection and reporting of information in one place
- Briefing of other parties such as inspectorate, check inspectors and mines rescue service
- Information communication
- Imperfect documentation and access to this documentation
- Currency of information
- Objective decision making
- Recording the decision making process to allow later review and revision as necessary.

Often small quantities of data, of limited accuracy were used in an attempt to establish the conditions existing in an inaccessible area of an underground coal mine. The prolonged nature of the management of incidents at Dartbrook Colliery particularly has lent itself to the development of mechanisms to improve the management of a number of issues. The author is grateful to Dartbrook Colliery for its permission to share with others some of the techniques developed and utilised by them.

Level One Exercises

One of the recommendations of the inquiry into the 1994 Moura No.2 underground coal mine disaster, was that an emergency response exercise be conducted at an underground coal mine each year. The aim of the exercise was to test the mine's internal emergency response system, the Queensland Mines Rescue Service and other external agencies' ability to respond and render assistance to the mine. Five such exercises have been completed. In addition to the level one exercise each mine is required to carry out emergency exercises based on operating sections (level 3) and whole of mine (level 2) annually. These exercises have led to significant improvements in the way mines prepare for emergencies and in their abilities to manage the incidents.

The level one scenarios were based on historical incidents and were tailored to conditions and situations that had already occurred at the mines, eg roof falls, friction ignitions etc.

The five exercises were: Southern Colliery 27 October 1998, Kenmare Colliery, 7 September 1999, Newlands Colliery, Saturday 25 November 2000, Kestrel Colliery 27 November 2001 and North Goonyella Exercise 4 November 2002.

Many valuable lessons have been learnt from these exercises including the move to compressed air breathing apparatus for in seam rescue and response. This paper will focus only on the issues as they relate to incident management. The findings of the exercises have been reported elsewhere (Rowan et al 1998 - 2002).

Issues from Level One Emergency Exercises & Significant Incidents:

Mine Environment Monitoring Systems

1. Despite the fact that all mines tested had computer based communications systems and gas monitoring systems, much of the communication was done verbally and transmitted via handwritten notes. This lead to a number of significant delays in obtaining appropriate information and on occasion incorrect information was obtained. Often the gas monitoring data was only displayed in the control room. The full capabilities of the gas monitoring software and computer system were not used.

2. No one person had the responsibility for obtaining and analysing ventilation and gas concentration data. No one had responsibility for ensuring the quality of the data. Often key decisions were made without any understanding of the limitations of the data being used as the basis for those decisions.

3. In most cases, the gas monitoring alarms in control room were submerged in the list of all alarms and not easily distinguished.

Information Flow/Record Keeping

4. Often there was no accurate information flow. This extended beyond gas information and include vehicle and personnel movements and locations. There were no effective recording procedures or logs of actions nor records of decisions with reasons or evidence supporting those decisions.

5. There was often limited or no control over communications into and out of the incident management room. Briefings of Incident Management Team (IMT) personnel were often unstructured.

6. On a number of occasions there was ineffective communication of information to Mines Rescue Superintendent and to rescue teams and other key personnel. The integration of rescue team organisational issues into IMT decision-making may have provided improved rescue effectiveness.

7. Inaccurate recording of persons underground and movement and location of persons underground. There was a lack of formal method to record and update the status and deployment of resources for rescue operations.

8. On most occasions important incident management decisions were not made until the mine manager or SSE arrived on site – in some cases causing delays of over two hours. Information was transmitted to the senior official offsite by phone. There were several instances of incorrect information being received by the mine manager because of this.

Incident Management Room

9. In a number of exercises the Incident control room was poorly resourced, with limited provision of white boards, accurate mine plans, desktop space, communications facilities and security against intrusion.

Decision Making

10. All too often there was no record kept of the decision making process.

11. Decision making occurred over too long a time period. There was no sense of urgency, direction or focus – which could be best provided by a clearly stated (and written up) set of Goals, Objectives and Priorities.

12. On more than one occasion there was the development of a Group Think mentality for decision making.

13. Rarely was a formal decision making process established. Little use was made of formal risk assessments in relation to the establishment of mines rescue operational limitations.

14. On at least two occasions, the disjointed flow of people into and out of IMT rooms made it difficult for any risk management assessments to actually reach conclusions.

Duty Cards

15. In general the use of duty cards was ineffective. The relevance of duty cards needs to be critically evaluated, as key personnel often did not consult their duty cards at any time during the exercises.

IMT

16. In general there was inadequate provision made for the changeover of the IMT personnel as they became fatigued. Fatigue became a key issue with the IMT as the incident became protracted. The change over of the IMT under these circumstances was never very effective.

17. There was a wide range in the size of the IMT from 2 persons up to 20. There is evidence from the exercises that a group of about 5 persons is most effective, with subordinate groups functioning outside the IMT but reporting back.

These issues lead to the identification of a number of key areas for improvement:

1. Better access to site policies and procedures – both onsite and offsite.
2. Better sharing of information relating to the incident, both on and off site.
3. Objective decision making, including records of process and rationale.
4. Quicker response to incidents.
5. Better focus in IMT – reduction in disruption.
6. Better equipped IMT, to be able to undertake the decision making processes required.
7. Better briefing capabilities to third parties , whether they be relief IMT, mines rescue or other personnel even off site.
8. Improved record keeping.
9. Systematic information flow and analysis.

Developments

A number of these issues have been addressed through an Australian Coal Association Research Program funded project looking at significant incident, investigation, evaluation and analysis. This project has focused on improving the application of electronic technology to assist in the management of significant incidents.

Key tools are:

A. Electronic Books – e books

Information sharing can be significantly improved through the use of electronic books on site computers, pocket computers and available offsite through the internet. These electronic books provide access to site procedures, response plans, trigger points, expert assistant databases and contact lists. The electronic documents permit good version control and restrict modification. Electronic books are very similar to web documents, the key feature is that they operate like paper documents with pages. In addition they are formatted in large size fonts with plenty of white space to enhance their readability. Access is easy via the title page and the table of contents.

An example of an e book as displayed on a Pocket PC is shown in Figure 1 below.

MS Reader is a free program from Microsoft that also acts to convert standard Microsoft Word ® documents into e books at the push of a button. There are a few hidden traps, so the final project report will include a user guide on how best to prepare documents for conversion.

Readerworks is a slightly easier to use and more robust piece of software that does the same job but costs about $ 150 AUD. It also offers a little more flexibility of operation. Both programs are easy to become proficient in.

It is envisaged that the required documents would be accessed via shortcut icons on the user's computer screen.

One of the side benefits of these software is that the e books automatically can be transformed to fit on the pocket pc's.

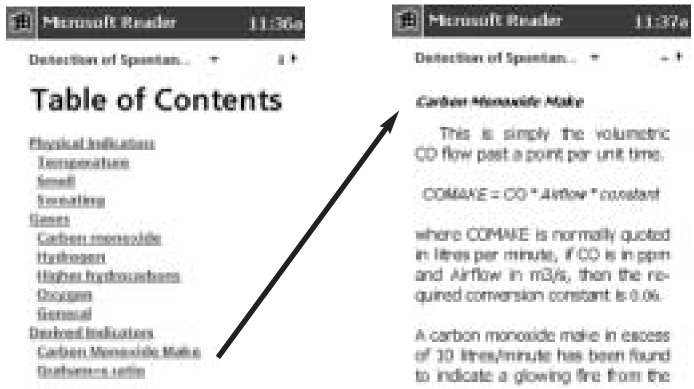


Figure 1: Example of e book screens from a Pocket PC.

B. Pocket Computers

Personal pocket computers have been utilised in this project to increase the portability of data communication and speed up the incident initiation process. This reduced the delays in responding to incidents. Windows CE compatible devices carry not only the e books but also full internet, email and abridged Microsoft Office software. They are full micro computers running Pentium central processors with many megabytes of memory. This allows for gas interpretation to be done anywhere and the results communicated electronically.

They have their own 56 k modems and can communicate either via Blue tooth technology or infrared technology to other devices including mobile phones.

In an emergency they could:

- Carry all the necessary phone numbers and contact details of relevant personnel. The devices can automatically synchronise with contacts databases kept on a computer in Outlook® or similar
- Be able to connect to internet to collect latest information and send emails via Outlook®
- Access relevant procedures, duty cards and other documentation to assist in speedy implementation of emergency procedures via e books
- Perform calculations on gas concentration data to allow interpretation offsite, using quick data entry as demonstrated in Figure 2 below.

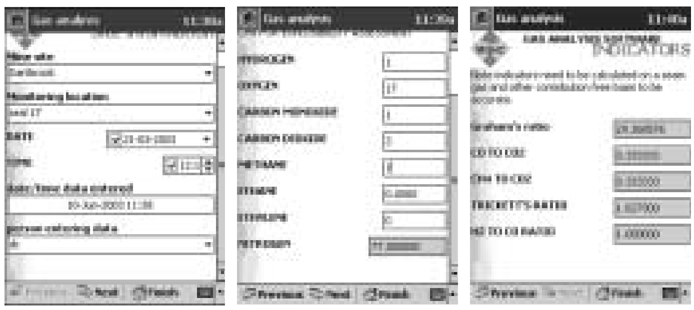


Figure 2: Data entry and analysis screens from Pocket PC Gas Analysis Software.

The gas analysis program displayed above was constructed using a front end program called Pocket PC Creations ($ 130 AUD) which uses an MS Access like set of commands to create data entry and processing. The program was constructed in approximately 1 hour and can be modified to include any ratios or other indicators that are considered necessary by the user. The data are stored in files that can be quickly extracted by the host PC when the Pocket PC is synchronised and the data are retrieved via Excel® allowing more sophisticated analysis and graphical trending to occur. The graphics capabilities of the Pocket PC's are currently being investigated.

C. Generic Computer Software

In addition to the e books mentioned above, improved information sharing and reduction in disruption of IMT can be obtained through the use of generic computer software that tracks and displays key incident information, and assists in the decision making process by providing a systematic framework to progress the decision making that at the same time keeps a record of the steps taken in making the decision.

Increased use of computers allows sharing of information between a number of locations both on site and indeed anywhere around the world. This in turn facilitates briefings of key groups such as mines rescue or government mine inspectors without disrupting the IMT. Information can also be entered from these areas without disrupting the IMT, which then optimises the decision making process.

This technology can reduce the delay in responding to an incident, which is crucial in saving lives and preventing incidents worsening.

Incident Decision & Event Logging Software

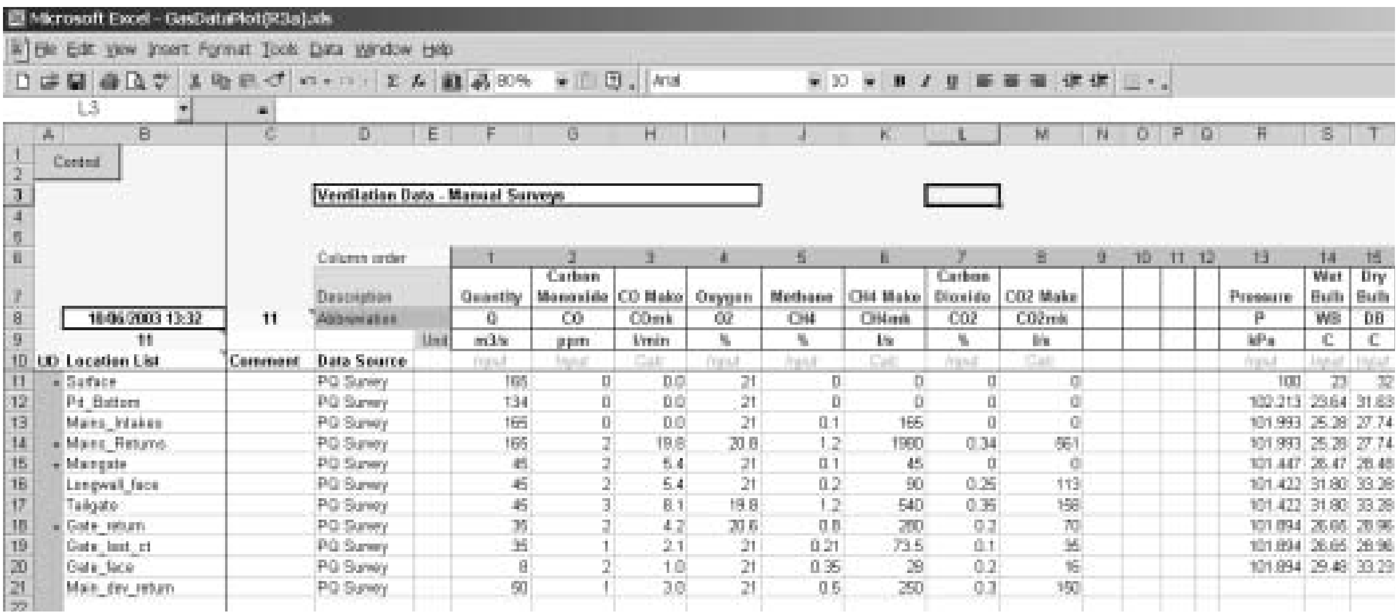
One thing that often is missing from Incident Management Processes is an effective way of logging actions and events, who is responsible and when they are closed out. Dartbrook Colliery have used a simple Excel® spreadsheet utilising the auto-filter function for the columns. Typically the columns used are: date and time, category such as inertisation or drilling, action, who is responsible, complete (Y/N), and comments. This allows quick sorting of the outstanding actions - by those that are not complete, or by category. This also provides a trail of decisions and actions.

Mines are encouraged to develop their own versions that suit their needs. Of course, being a computer file it can be accessed from a range of locations, and emailed etc. This would speed up briefings and allow persons outside the IMT to become aware of the status of an incident without the need to disrupt the IMT or its decision-making processes. The maintenance of the integrity of the IMT would also be enhanced with the following software that allows sharing of other information around a mine site and beyond.

Investigation Software

Simple computer software (generic) has been developed to allow quick and simple acquisition of key mine environmental monitoring information, again accessible over the net, both intra and inter. This software has been developed in Excel ® so that it is not subject to proprietary concerns or huge costs. In addition, as the software is in Excel®, there should be no barrier to sites will customising the software to their own needs. It can also be used to track the movements of vehicles and persons underground. User guides will be provided as part of the final report to ACARP. Using this software every site has the capability to easily electronically collect and display key information. This information can also be shared offsite readily. These programs could be linked to more sophisticated data analysis packages such as SEGAS PRO, SMARTMATE or HGAS. It is not intended to replace these packages merely to enhance the overall site capabilities for analysis and interpretation.

The data entry to the spreadsheet-based program can be manual or via continuous update per dynamic data exchange facilities available with most PLC run systems. The data entry screen and a typical display screen are outlined in Figures 3 and 4 below. These displays can be tailored to individual needs. Access to the program can then be via the site intranet or on a stand alone PC and the files can be emailed off site for external scrutiny and advice. A user guide will be provided for the package as part of the final report to ACARP. However, the actual program is merely intended to demonstrate what can easily be achieved and it is intended to leave the details to site personnel to create and maintain.



Ventilation Data - Manual Surveys

Location List	Data Source	Quantity Q (m3/s)	Carbon Monoxide CO (ppm)	CO Make COmk (l/min)	Oxygen O2 (%)	Methane CH4 (%)	CH4 Make CH4mk (l/s)	Carbon Dioxide CO2 (%)	CO2 Make CO2mk (l/s)	Pressure P (kPa)	Wet Bulb WB (C)	Dry Bulb DB (C)
Surface	PQ Survey	165	0	0.0	21	0	0	0	0	100	23	32
Pit_Bottom	PQ Survey	134	0	0.0	21	0	0	0	0	102.213	23.64	31.63
Mains_Intakes	PQ Survey	165	0	0.0	21	0.1	165	0	0	101.993	25.28	27.74
Mains_Returns	PQ Survey	165	2	19.8	20.8	1.2	1980	0.34	561	101.993	25.28	27.74
Maingate	PQ Survey	45	2	5.4	21	0.1	45	0	0	101.447	26.47	28.48
Longwall_face	PQ Survey	45	2	5.4	21	0.2	90	0.25	113	101.422	31.80	33.28
Tailgate	PQ Survey	45	3	8.1	19.8	1.2	540	0.35	158	101.422	31.80	33.28
Gate_return	PQ Survey	35	2	4.2	20.6	0.8	280	0.2	70	101.894	26.65	28.96
Gate_last_ct	PQ Survey	35	1	2.1	21	0.21	73.5	0.1	35	101.894	26.65	28.96
Gate_face	PQ Survey	8	2	1.0	21	0.35	28	0.2	16	101.894	29.48	33.23
Main_dev_return	PQ Survey	50	1	3.0	21	0.5	250	0.3	150			

Figure 3: One of the data entry screens from the visualisation software.

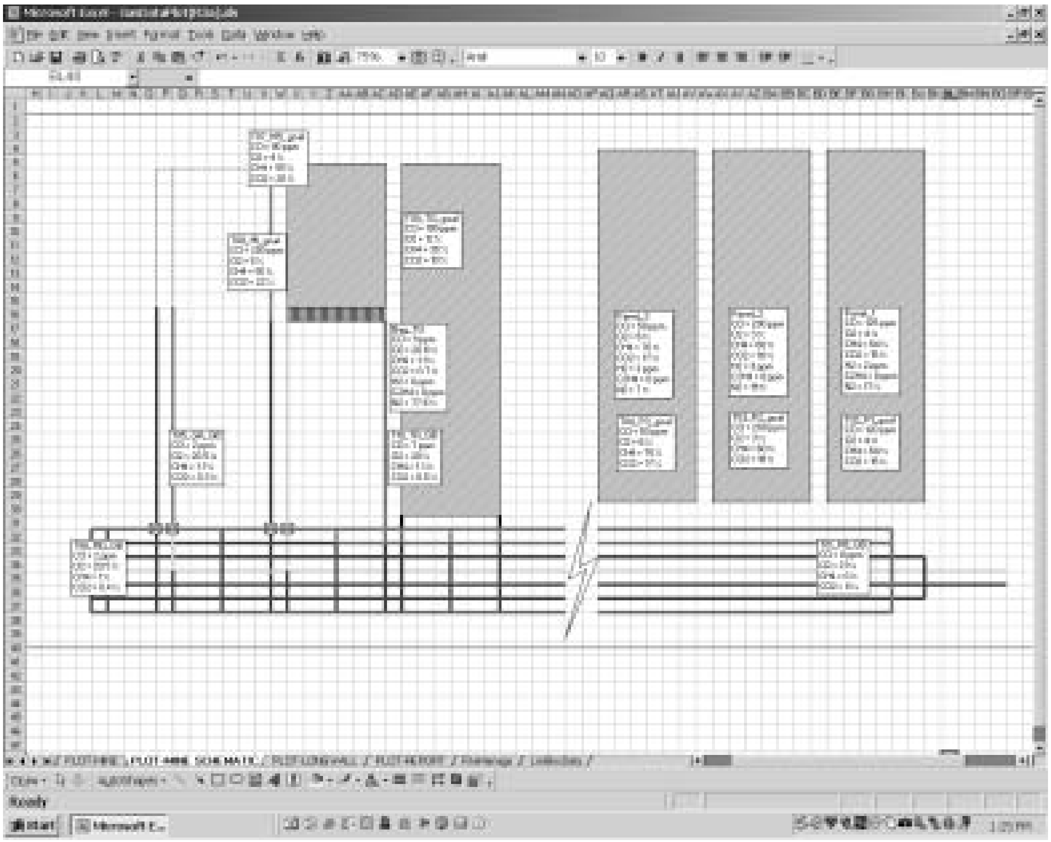


Figure 4: One of the possible data display screens.

minor modification and validation of areas of uncertainty before it can be used to assist in the decision making process. Examples of these trees could include the sealing of a longwall panel, a vehicle fire, belt fire, spontaneous combustion in a goaf, or an outburst.

The Future

A logical extension of this project would be to expand the capabilities of the system to record the actions of mines rescue teams and plot their progress during incidents, keeping track of time under supplied air etc. Mines rescue guidelines will be converted to e book format for ease of use. This project extension is the subject of an application for funding to ACARP at present.

The key to the program is a series of macro commands that translate data into graphic boxes that can be displayed on mine plans. This enables better visualisation of incidents. Using the drawing feature in Excel®, other features can be added such as the location of faults or personnel. Figure 4 was entirely created within Excel®. The graphic boxes are fixed in location relative to each other which allows for zooming in and out of the display.

Decision Making Assistance

A number of free or low cost decision-making and logic tree programs have been trialed to assist in more effective decision making. Decision trees have been developed for a number of scenarios. These will be provided to ACARP as part of the final report and may be used as templates if appropriate. These software track the decisions made and log the rationale behind each decision. Figure 5 shows an example of the simple graphical output from one of these computer programs - REASON!ABLE®.

This program can then be used in evaluation mode to assist in the decision-making process by documenting the ranking of the reliability and degree of certainty of the decisions as shown in Figure 6. This in turn allows a degree of certainty to be attached to decisions and also areas that need clarification can be quickly identified.

The decision-making process has deliberately been left in the control of the IMT. The electronic devices merely provide aids to improve the quality and the speed of the decision making process.

They also provide a record of the process for external review and revision.

It is hoped that for the major risk scenarios at each mine the essential decision trees will be determined in advance. Should the scenario actually eventuate then the tree would only need

Conclusions

This project has demonstrated that we can significantly improve the management of significant incidents by the use of simple computer based programs that remove the need for verbal or paper communications and reduce time lost in collecting and providing information to various parties. The use of Pocket PC computers can increase the portability of information and can significantly reduce the delays in effectively responding to significant incidents.

These tools, in their current format, should only be viewed as a starting point for sites to take and develop themselves, as appropriate to their needs. Development requires no specialised computer skills or expensive proprietary software.

The project aimed to demonstrate how this could be achieved but not dictate how it must be done. The responsibility for making decisions resides with the IMT, but hopefully these tools will make their job easier.

One of the key issues with such tools is maintaining familiarity with its use; if it is only used during a significant incident then people will forget how to use it. All the tools outlined above can equally assist in the day operation of the mine and should be used regularly, for example: during routine sealing of a panel.

Acknowledgements

The author gratefully acknowledges the input and feedback from a wide range of industry personnel and in particular Dartbrook Colliery for sharing their experiences. The funding by ACARP has made this project possible. The contribution of Roy Moreby in developing the spreadsheet program is also gratefully acknowledged.

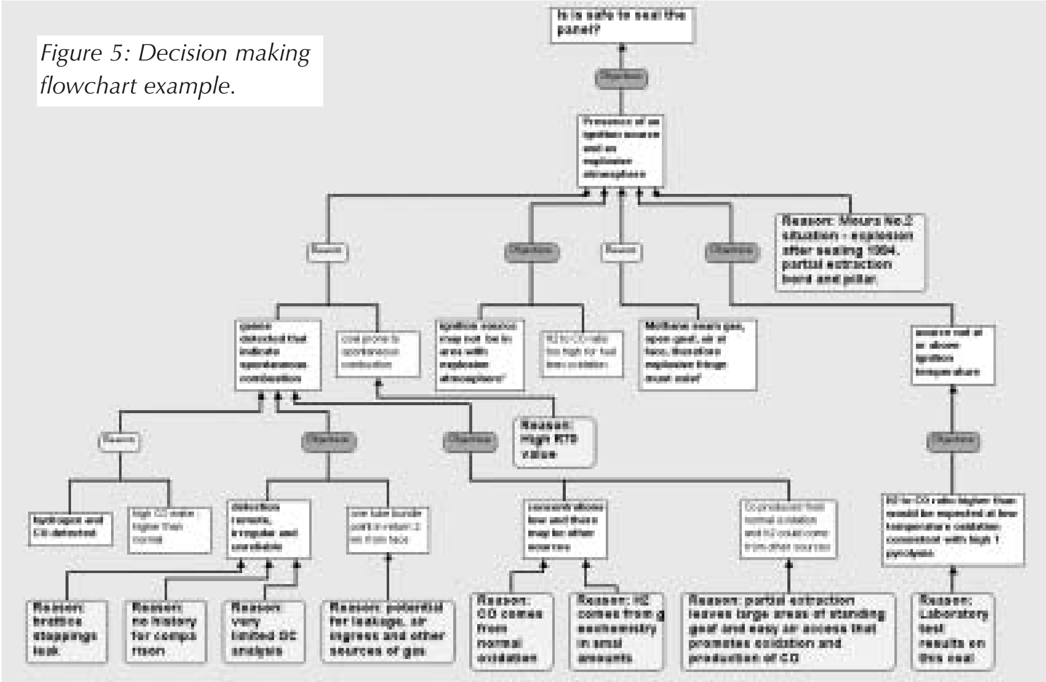


Figure 5: Decision making flowchart example.

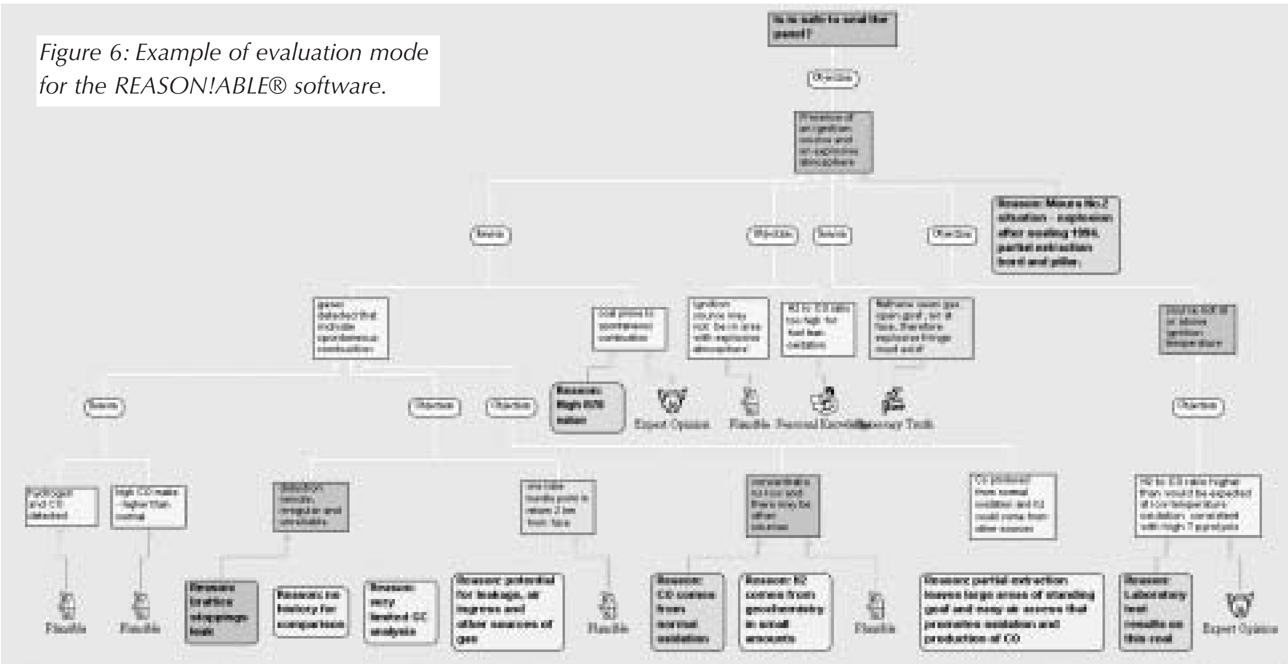


Figure 6: Example of evaluation mode for the REASON!ABLE® software.

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Using Knowledge Management to Improve Risk Management Strategies & Communications in Mines

Hayden Cater, Department of Primary Industries

Introduction

The management of health and safety risks, the effective communication of risk management strategies and their controls are key issues for all Australian mines. Most states are adopting performance-based legislation for the management of health and safety. This approach places significant duties on employers and mine managers to effectively manage health and safety. The approach of performance based legislation is one of hazard identification, risk assessment and control and requires mines to implement management systems and procedures to control mining risks.

The setting out of duties for employers and employees as well as the use of risk management as a basis of health and safety legislation has been in vogue for the past twenty years. Most mining companies have a risk management program with a risk register, procedures and processes to identify, assess and control risks. Significant resources are put into the management of health and safety risks in the mining industry. So after many years of using risk management processes to manage health and safety risks how are we going? Well it would seem that we still have a long way to go. As an industry we have high rates of injury and many employees are still being killed as a result of workplace accidents compared to other industries. Last year there were seven fatalities in the Australian Minerals Industries (Minerals Council of Australia, 2003, p 2).

In Australia high occupational injury and illness rates are undermining our economic performance and reducing living standards and the value of undertaking health and safety risk management is being increasingly questioned (Viner 2002, Tillman and Robinson 2002, Harvey, 2002, Cross and Trethewy, 2002).

At a national level the Occupational Health and Safety Commission (1999: p 1) estimates more than one million working weeks were lost in 1996 - 97 due to work-related compensated cases. In comparison, working days lost annually due to industrial disputes totalled only 650,400 in 1999 (Australian Bureau of Statistics, 2001 [on-line]).

Risk Management in Mines

Mining today involves the use of cutting edge technologies, new equipment, changes to work processes and staffing arrangements. To survive and be profitable in a competitive environment mine management and employees must be flexible and move quickly. This involves making constant and ongoing changes to the working environment. This can place unrelenting pressures on the management and employees of a mine to remain competitive. These developments also have the potential to introduce new hazards and risks to the workplace.

To combat these problems the use of risk management is growing. It is used by many mines not only as a method of managing health and safety risks but also as an effective way of coping with a more volatile economy, rapid changes in technology, new equipment and avoiding costly mistakes.

Effective risk management on mine sites however is more than just developing a procedure, undertaking risk assessments and having a risk register. Mines should develop strategies to regularly review their risk management profile. This means conducting a review or audit of what the mine needs to know about the risks on site, identifying any gaps in its risk management strategy and developing controls to ensure all risks are effectively controlled. As the workplace is constantly changing mines also need to determine what their people know about health and safety risks and how that knowledge can be used by the organisation to reduce risks. An effective risk management strategy also needs to ensure that the nature of the risks and their controls are communicated to the workforce.

At the same time the use of risk management is increasing, the management of health and safety risks is becoming more complex and difficult and there are signs that many organisations are having difficulty managing risks using old techniques and paradigms because of the volatility and pace of change in the economy (Smallman 1996: p 246). Mining is not immune to these pressures. Covello (1986: p 441) sums up the current debate about risk management and asks, "in response to the changing economic conditions and the effects of globalisation are the traditional methods of managing risk and communicating risks adequate?" He suggests that to cope with the demands of the new economy and performance based legislation we need to seek improved risk management techniques and concepts. Knowledge management may be the key to unlocking those improvements.

The principles of knowledge management can be used to develop improved risk management techniques and concepts. Organisations including mining companies should consider developing a knowledge management strategy to cope with our fast moving and competitive economy (Chorafa 2001: p 3). Knowledge management can be applied to health and safety risks and it has the capacity to contribute to the bottom line of a mine through improved risk management, better risk communications and enhanced organisational problem solving capacities.

What is Knowledge Management?

Before we discuss knowledge management it is appropriate to discuss what is knowledge in the context of the workplace and provide an overview of what we call knowledge management. The Macquarie Dictionary (2003, p 1054) defines knowledge as "the fact or state of knowing ... that which is known, or may be known". Von Krogh, Ichijo and Nonaka (2000, p 6) go further than this and argue that knowledge (what is known) can be in two basic formats either tacit or explicit.

Explicit knowledge can be referred to as knowledge that has been recorded as information in a document, image, computer data, film clip, photograph or in some other medium. It can be put on paper, formulated in to sentences, or captured in drawings and specifications (Von Krogh, Ichijo and Nonaka 2000, p 6).

Tacit knowledge refers to knowledge that resides in a person's mind and can include aspects of culture or 'ways of doing things' (Standards 2001 p 7). It can also be tied to the senses, skills in body movement, individual perception, physical experiences, rules of thumb and intuition (Von Krogh, Ichijo and Nonaka 2000, p 6).

In the workplace knowledge management can be seen as a processes of sharing, acquiring and creating knowledge to solve organisational problems (Standards Australia 2001, p 5). Collision and Parcell (2001 p 8) refine this definition and state that knowledge management is the "capturing, creating, distilling, sharing and using knowledge. This definition includes both tacit and explicit knowledge and provides a good working definition of what knowledge management means within organisations.

Developing a Knowledge Management Strategy

A knowledge management strategy sets up a framework to assist with implementation process and provides a road map for the organisation to follow and measure progress against. Like risk management the components of a knowledge management strategy can be divided into a number of interconnected steps. Figure 1 describes these interconnected steps.

1. Create a vision – set the scope of the project. Establish the goals and objectives
2. Form a project team
3. Map the organisation
4. Conduct a knowledge management audit
5. Review the results – identify gaps
6. Select pilot projects or identify health and safety or risk management initiatives
7. Map knowledge needs
8. Provide resources
9. Connect across the organisation
10. Review and continually improve.

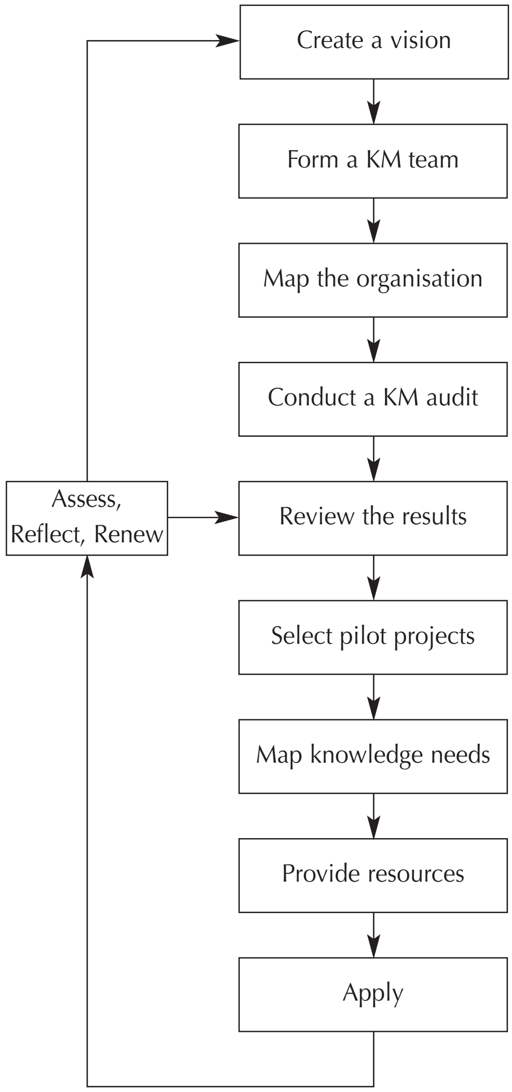

Figure 1: Overview of Knowledge Management Process.

Implementing a knowledge Management Strategy

Once you have decided to implement a knowledge management strategy it is useful to create a vision statement to define what you actually want to achieve. A vision statement should describe the overall aims of the strategy and set out the major supporting concepts that will be used to achieve it.

Maping the Organisation

The next step in the process is to identify and document its current knowledge-based resources and capabilities. This is called mapping and it will identify what knowledge is currently available and how it is being used within the organisation. Mapping the organisation should clearly identify:

- Where are all of the business units within the organisation are located
- What their main functions are
- What are the main tasks undertaken in those areas
- Who are their key personnel in those areas
- What are their areas of expertise
- The organisational mapping can also include all all-major processes, technologies and equipment.

In risk management terms this is known as establishing the risk management context.

Knowledge Management Audit

Once the organisation has been mapped an audit of each business unit or process should be conducted. This will determine how the organisation is currently managing its health and safety risks and knowledge. The audit should include what knowledge is available about controlling these health and safety risks and what knowledge should be collected, acquired or created. A knowledge management audit can reveal potential knowledge gaps in the management of health and safety risks. Several techniques can be used to collect data such as questionnaires, focus groups and critical incident technique.

Issues that could be raised during the audit include:

- What are the organisation's highest health and safety risks?
- What controls are in place to manage these risks?
- Are these controls effective?
- Why/why not?
- What could be done to improve the management of specific health and safety risks?
- What could be done to improve the overall management of health and safety?
- How do you find out about health and safety?
- Is this source reliable?
- What is the best source of health and safety information?
- How could health and safety communications be improved?
- Where are health and safety resources located?
- What specific skills people in relation to business functions, health and safety and health and safety risks?

Although many organisations will already have comprehensive hazard and risk registers. What they may not have done is to subject them to this level of intense scrutiny and review. The objective of the knowledge management audit is to identify strategic gaps in the health and safety risk management process and discover opportunities for improvement.

The results will also form a baseline measurement of how the employees of the organisation perceive how health and safety communications and knowledge is managed within the organisation. Auditing offers opportunities for identifying methods of improving communication and safety management.

Identifying any Knowledge Gaps

The results of the knowledge management audit should be properly documented. Once this is done a gap analysis should then be conducted on the results of the audit. The purpose of the gap analysis is to identify what knowledge is currently available against what is required to effectively manage health and safety risks. The audit should also identify any individuals and resources with particular knowledge that can assist the organisation to achieve its goals.

A gap analysis should be conducted against:

- Current risk management policies, procedures and processes
- Existing health and safety Hazard and risk registers
- Known sources of health and safety knowledge the effectiveness of specific controls including procedures
- Perceived health and safety needs
- The level of training provided/required
- Communication methods.

The collection and analysis of this information will assist with current risk management activities and future projects.

Knowledge Management Projects

Once the knowledge gaps within the organisation have been identified through the audit, projects and project teams can be developed to apply knowledge management to various health and safety and risks. Projects that could be developed include:

- Improvements to the overall risk management processes
- A comprehensive review of hazard and risk registers (breadth and depth)
- The review of scope, application and completeness of health and safety polices and procedures
- The effectiveness of current risk controls
- Benchmarking of health and safety systems, risk processes and performance
- Investigation and identification of new controls
- A review of documentation systems
- Identification and recording of tacit information
- Developing skills and knowledge inventories
- Recording and restructuring of explicit knowledge into a more useable format
- Improving communication methods
- A review of general and specific training needs.

Establish Project Teams

The next phase of the strategy is to implement the findings of the gap analysis. This is done by establishing project teams to work on specific health and safety projects. These teams should be cross-functional if possible to spread the benefits of the projects as widely as possible. Leaders or champions of the group should be identified to facilitate the process for specific issues. The leaders or champions should be briefed on their role and how the projects will be rolled out. This is a crucial phase of the implementation strategy and adequate resources should be provided to ensure the success of the project.

To avoid different project groups working in isolation the organisation should develop strategies to enhance communications not only throughout the organisation but also within the teams themselves. The development of discussion or focus groups, inter-team briefings, internal newsletter or web-site can be used to help communications. Many sites are part of larger organisations and a dedicated web could be created so that all sites can access and share information. The web site could form part of an existing portal or be an entirely new site.

Team Based Tools

There are many team-based tools that can be used to support an implementation strategy.

Peer Assist

Peer assist is a meeting or a workshop where people are invited from other project teams to share their experience, insights and knowledge with a team who have requested some help. It is worthwhile holding a peer assist when a project team is facing a challenge, where the knowledge and experience of others will really help. A peer assist:

- Targets a specific or technical or commercial challenge
- Gains assistance and insight from people outside the team
- Identifies possible approaches and new lines of inquiry
- Promotes sharing and learning with each other
- Develops strong networks amongst staff.

Benchmarking

Benchmarking against other business units and organisations. Benchmarking can be on specific issues such as high risks, developing controls, communication strategies etc to acquire knowledge.

Workshops & Discussion Groups

Knowledge workshops and focus groups are conducted within and across teams to share and create knowledge. They can be used to evaluate current risks, identify risks associated with new innovations or changes to the workplace. They can be similar to an in depth after action review. They do not have to be limited to what went well. They can also be used to discuss what could have been done better and what would be done different next time.

Discussion groups and inter team briefings are less formal and are also used to promote knowledge throughout the organisation. New and innovative approaches to managing risks can be discussed.

After Action Reviews

After Action Reviews (AAR) are a deliberately short and sharp discussion and analysis session designed to aid team and individual learning. The United States army first developed the process. The purpose of the AAR is to improve the ability of soldiers to learn from the midst of action and to improve team working. "An after action review is a professional discussion of an event, focused on performance standards, that enables soldiers to discover for themselves what happened, why it happened, and how to sustain strengths and improve on weaknesses" (Collision and Parcell, 2001, p 77).

The format is quick and simple and should not take more than twenty minutes. The AAR answers four simple questions:

- What was supposed to happen?
- What actually happened?
- Why where there differences?
- What did we learn?

Web Based Tools

Web based tools allow work groups to connect across functional boundaries, time zones and distance. These sort of tools are very useful for geographically isolated people and sites. They allow people to become part of a community of knowledge and if they are properly structured to have access to large support networks.

Corporate Yellow Pages

Corporate yellow pages are more than just a telephone directory. They are a searchable database where people can look for staff with relevant knowledge and experience. Corporate yellow pages can assist people to find the right source of information at the right time. Typical information in corporate yellow pages can include:

- Name, Job Title, Position
- Contact Details
- Photograph
- Structured Taxonomy of 'areas of expertise'
- Free text area
- Internal and external web links
- Qualifications
- Membership of networks and teams.

To cut down of the time it takes to set up a corporate yellow pages many organisations have developed easy to fill in templates for people to fill out. Useful information may also include areas that are currently working on and past projects.

Health & Safety Knowledge & Risk Management Web Site

A knowledge or risk management site can be used to improve communications contain links to corporate information, provide opportunities for assistance and requests for help. Content could include:

- Overview of the KM project
- Results of the KM Audit
- KM Data base – Yellow pages
- Details of projects
- Org chart and project teams
- Ask the KM team questions
- What's new – messages from the team – photos etc
- Help page – post questions and offers of help
- Outside links.

Practical Knowledge Management

Knowledge Management is not just a concept or fad. It has practical applications for a range of risk management situations in the mining industry such as training, physical hazards and emergency management. All mines will have an emergency management plan and should conduct emergency response exercises. Many will also have a duty card system with documented roles and responsibilities for key personnel. Although such cards and exercises are of great value and can be used to prepare for emergencies they may not always cover every contingency or issue that occurs during an emergency situation.

In the event of an emergency or crisis situation how well would your mine handle it? How prepared would you be and do you know everything you need to know to deal with and emergency situation? Emergency planning and response is one area that knowledge management can be used at a practical level to improve a key risk management or safety issue.

All mines have a wealth of knowledge and experience but how often is it left to the mine manager or health and safety officer to develop and review the mine's emergency management plan. How often do these people get the time and resources to find out what people know and what skills they have. By using knowledge management techniques to map, audit and identify any gaps in the emergency management processes mines have an opportunity to make their emergency response plan and teams more effective and efficient.

Getting Started

A knowledge management project team reviewing an emergency management plan may need to consider some or all of the following issues:

- Emergency management team
    - Do you have the right people with relevant knowledge of the events or hazard?
    - Do you have access to relevant technical experts and information?
    - Are these people available when needed?
    - Do you have the right number of people to handle a crisis?
    - Do these people need training, in what, where can we source it?
    - Are there any gaps in the team or its training?

- Hazards and risks
    - Have all hazards and risks been identified and assessed?
    - Are they included in the plan?

- Emergency communications
    - Who is responsible, are people trained?
    - Are there adequate mine communication systems including:
        - Telephones
        - Radios
        - Fax
        - E-mail
        - Back up communications if services fail (electricity, phones)
        - Back up power supply?

- Coordination of emergency services
    - What services are available, who deals with them, are our employees members of a particular service?
    - Who is responsible for communication, maintaining relationships, training and liaison with external officers?
    - Are these groups familiar with the mine?
    - Have they been inducted/do they need to be?
        - Police
        - Security
        - Ambulance
        - Doctors
        - Hospital
        - Fire fighters
        - Mine rescue
        - Flying doctor
        - SES
        - Coroner
        - Mines Inspectorate

- Provision of emergency equipment
    - What is needed, where can we get it, is it always available?
    - Is additional rescue equipment required in specific circumstances?
    - Do we need specialist equipment e.g. Jaws of Life, rescues from height etc?
    - Do we have people that can use it?

- Management of regulatory investigations
    - Are there adequate?
    - Facilities including communications available
    - Liaison officer (s)
    - Notification and reporting requirements

- Local medical services
    - Do they know what to expect?
    - If there is an overflow what happens?

- Managing the media
    - Who is authorised to speak?
    - Who writes any press releases?
    - Who are our contact personnel?
    - What should they say?
    - Who should be let on site?
    - What security do we need?
    - Do you have stock footage of the site to provide to the media?
    - Do you have responses and explanations for key questions?

- Debriefings for those involved
    - Debriefings/information for relatives
    - Coordination of employee/family assistance and support
    - How do we handle distraught family?
    - How do we deal with fatalities?
    - Where would we put any deceased while we treat the casualties?

- Internal Investigations
    - Who shall conduct them?
    - Are people trained?
    - Collection and preservation of evidence
    - Report writing and photographs
    - Self incrimination.

- Business continuity
    - Are alternative plans needed to ensure that the mine keeps operating (if appropriate).

The scope of the knowledge management review should be appropriate to the size and complexity of the mine. This can be done using the above list as a starting point. Once the scope of the review has been decided the team should map the current situation of the mine and conduct an audit of knowledge and skills associated with emergency management.

Once this is done the team can then begin to identify any gaps in the emergency management plan and then develop a strategy to improve how the mine manages its potential emergency situations. Once a plan has been developed a range of team and web based tools can be used to implement the plan. Appendix A contains a suggest contents of an emergency management plan.

Conclusion

Mining continues to face many challenges including performance based health and safety legislation, new technologies and the ever-increasing demands of the new economy. As organisations seek to become more efficient to remain competitive they will need to break out of traditional risk management approaches and find new ways of doing things. The mining industry will need to look outward to other sectors to find new ideas and tools to adopt.

This paper has outlined some basic knowledge management concepts and provides a hands on example of how to apply knowledge management to a specific health and safety risk management issue. Whilst knowledge management is not a definitive answer to the problems of managing health and safety risks it is an important and useful tool in the war against occupational injury and disease. Knowledge management techniques can be used by mining companies to improve risk management, communications, health and safety management systems, processes and to share knowledge between sites.

Individual sites are able to use knowledge management techniques for site specific projects including training, risk management and task analysis as well as physical hazards such as plant safety, electricity, hazardous substances, noise and manual handling. Knowledge management can also be used to re-invigorate a flagging or complacent risk management programs, improve the quality of risk control options and promote better risk communications. Knowledge Management represents an important step forward in improving health and safety risk management and communications.

Appendix A: A Suggested Emergency Management Checklist

Site and Hazard Details	1. Name location, address and nature of operations 2. The name, title and telephone number of the person with whom the details of the plan can be verified with 3. Detailed map of the mine and surrounding area 4. Listing of hazards (including cumulative hazards) – types of emergencies 5. Minimum / maximum number of persons expected at facility including shift arrangements etc 6. Infrastructure likely to be affected by major incident including control points for utilities 7. Emergency planning assumptions 8. Description of measures of control the consequences of each hazard and major incident
Command Structure	9. Command structure and philosophy for emergencies 10. Details of emergency contact personnel 11. Details of the person responsible for liaison with the emergency services 12. Allocation of personnel for implementing the plan including their roles and responsibilities of all personnel involved in implementing the plan (duty cards) 13. Location of command centre (s)
Notifications	14. Procedures for providing early warning of a major incident 15. Details of on-site and off-site warning systems 16. Contact details for emergency services 17. Details of on-site communications systems
Resources	18. Details of emergency resources on site including resources for specific hazards 19. Arrangements for obtaining additional resources 20. Systems to ensure that persons trained in the use of rescue equipment are available on site, or are on call whenever any person is working at the mine 21. Details of rescue equipment
Procedures	22. Systems including procedures that enables all persons within the mine at any given time to be promptly located 23. Procedures for safe evacuation and muster of personnel 24. Details of control points and procedures for essential services 25. Procedures for the containment of any incident
Systems	26. Procedures for testing the emergency plan in order to ensure its continued effectiveness 27. Arrangements for the emergency services who have responsibility for the area in which the mine is located to participate in those tests 28. Procedures for the review and audit of the Emergency Management Plan 29. Procedures for the provision of information, instruction and training of employees, contractors and visitors to the mine 30. Procedures for the debriefing of employees and their families and providing assistance 31. Procedures for the update of the plan

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Challenge Test – Your Level 1 Emergency Exercise

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Abstract

The Level 1 Emergency Exercise has been conducted in Queensland Underground Coal Mines for the past five years and is a specific requirement of the Moura Inquiry findings.

The intent of this paper is to provide relevant information on past, present and future actions that will affect underground coal mines and their emergency response systems. It is also of value to other mines (open cut and metalliferous) where the hazards may not be the same yet suggestions and innovations may be utilised.

The paper is in four parts:

- Key recommendations from previous emergency exercises that warrant repeating for emphasis and as a backdrop the change process later in the paper
- The proposal for and initial operation of a modified program for Level 1 Emergency Exercises
- Findings and recommendations from the Emergency Exercise conducted at Crinum in July
- The experience from Crinum's perspective.

North Goonyella Recommendations – For Industry

It is not the intent nor is it appropriate to discuss the findings and recommendations of the North Goonyella Emergency Exercise from November 2002 in this paper (due to the author's non-participation in the exercise). This information has been detailed and reported by Mr Greg Rowan and the Management Team of that exercise and presented at industry forums since that time.

However, a selection of the recommendations from this and previous exercises are repeated here in order to reinforce the need for them to be addressed by mines. This is clearly a source of frustration and concern as expressed by Emergency Exercise Management Teams (EEMT's), industry personnel and the Mines Inspectorate.

Duty Cards

Duty card systems are an excellent aid for initial response to an incident and are widely utilised. However, there is a need to "walk through" the intent and operation of all the cards, ensuring effective interactions and identification of personnel, clear roles and responsibilities with no duplication, training in the various roles (including relief personnel and handovers) and clear feedback systems to the IMT.

Incident Management Team (IMT)

As the key focal point for any incident the IMT will attract a significant amount of attention, often due in part to hindsight and generally from people not in the "direct line of fire". Nevertheless, all exercises have highlighted the need for improved decision-making, communication and communication systems, data management systems and processes, fatigue management and clear lines of authority. The Emergency Preparedness Course as presented by both NSW and QLD Mines Rescue Services coupled with the regular simulated exercises will go some way to addressing this issue.

Simple knowledge of monitoring system response times is also being overlooked as a necessary piece of information in understanding an incident.

Incident Management Rooms

There is an ongoing need for effective tools and techniques (white boards, computer data bases, etc.) to assist in managing the situation as well as aiding in the briefing and decision-making processes. These must be of a style that suits the IMT best, but need to be developed and refined through simulated use.

Underground Response

Communication systems failings continue to arise – either between Control or IMT and individuals underground, mainly when Self Contained Self Rescuer's (SCSR's) are used, or simply between a Control Room and the IMT.

Gas analysis by underground personnel without instruments is regularly raised as a deficiency though not easily answered – a mine still needs a protocol even if it is as simple as "if in doubt assume the worst and use an SCSR".

Protocols for emergency response (as opposed to escape) need to be developed as appropriate as the use of Compressed Air Breathing Apparatus becomes more prevalent.

Previous Recommendations

The information provided by each emergency exercise is a "free kick" or early warning to all mines, so that if an unfortunate situation does arise, a mine may be somewhat forearmed. Better to learn from another's experiences than make your own mistakes – the industry appears to be slow in picking up the past recommendations.

A Challenge for the Organisers – A Change in the Process

A review of the existing Level 1 Emergency Exercise process was undertaken in March 2003 by a team representing mines, union and mines' inspectorate, with the objective of "maintaining relevance to current industry needs". The primary driver for the review was mainly recommendations from previous EEMT's as well as one of convenience in that the existing schedule would culminate with this year's exercise.

The reasons for the review are summarised below:

- 5 years since the original process was initiated and the schedule of events is now complete
- The standard for the exercises was initiated prior to the extended implementation of either oxygen SCSR's or CABA
- The need to test aided response as well as self-escape, given that CABA raises alternative strategies
- The need to test effectiveness of mine emergency systems not just escape. This is particularly targeting the IMT and associated protocols
- A general indication from stakeholders that it was opportune for a review and potential change in response to the above issues.

A range of key issues and concerns raised during previous exercises also needed to be addressed by the resulting proposal. These include:

- An excessive number of recommendations that are slow to be taken-up by industry
- Deficiencies in the IMT processes – changeover to relieving personnel; fatigue management; intra-team communication systems
- Artificial complexity within the exercise, due to the requirement to test all response capabilities in one exercise.

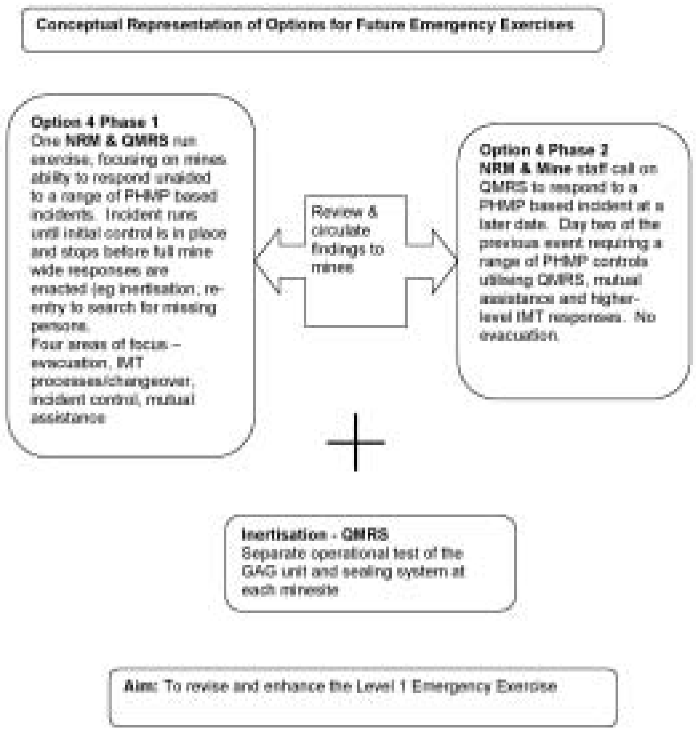
The original objectives of the Level 1 Emergency Exercise were reviewed and modified so that the intent would be clear for all stakeholders and to ensure that the resulting format suited the perceived needs of the industry. There has not been a significant departure from the original intent of the exercises, but more a refocusing on the current level of preparedness at individual mine sites with the view to future developments in techniques and technology. These objectives are as follows:

- Test each mines emergency preparedness capability at a high level – level 2 and 3 exercises are still to continue at every site
- Test the individual mine's Incident Management Team processes, decision-making systems and general responses
- Test the individual mine's systems rather than a standard system that fits all
- Allow for reality to drive the simulation, this includes – making it relevant to the mine's Principle Hazard Management Plans; if the exercise is well handled and controlled, let it runs its course to success; if it is catastrophically failing, curtail the exercise and critique with the management team.
- Test the mutual response process
- Test the Queensland Mines Rescue Service (QMRS) responses separately to the mines response
- Increase the level of QMRS involvement in the mine specific testing – the aim being to have senior mines rescue personnel closely aligned with planning and execution of the emergency exercise and therefore more intimately involved with individual mine's Hazard Management Plans then to provide a response capability at a later date
- Separate the inertisation phase and testing of the mine airlock operation from the emergency exercise
- Categorise the reporting and recommendations for easier industry implementation.

The Chosen Model

Three exercise options were considered and evaluated using a SWOT analysis. The option that was agreed upon (a fourth option) was a combination of aspects of the other three options.

The agreed option comprises a three-stage process as illustrated:



Phase 1

An emergency incident occurs underground requiring the full evacuation of the mine and un-aided response by the mine. The exercise is co-ordinated by the Department of Natural Resources and Mines and SIMTARS with high-level assistance from QMRS, CFMEU, NSWMRS and industry representatives. The exercise stops when control over the situation is demonstrated. The incident is to be as relevant to the mine as possible based on actual events that either have or could potentially occur at the mine. The incident should be designed in such a way as to challenge the operation of one or more of the mines Hazard Management Plans. Self-escape of personnel will be tested similar to previous exercises with the inclusion of a later (in the day) assessment of an individual's decision making processes. This is to give some added dimension and illumination for an individual worker as if they were required to make their escape entirely on their own abilities. The IMT responses will be closely scrutinised particularly targeting any perceived deficiencies in procedures following on from the EEMT's review of the management plans. This will be further analysed in the second phase particularly given the concerns raised by previous EEMT's with regard to IMT practices and protocols.

Phase 2

A new step, not without controversy. This will be an entirely separate exercise to Phase 1, most likely but not necessarily, conducted at a different mine. It will be, in principle, the next day or stage of an emergency incident following on from the mines initial evacuation. It will follow on from Phase 1 to some degree but will not exactly dovetail due to different mines idiosyncrasies. For instance, Phase 1 may see a mine fully evacuated due to a fire or explosion, Phase 2 could be the extended control of a fire situation due to spontaneous combustion, if the seam is so prone or the recovery of trapped mineworkers following the collapse of strata due to the Phase 1 fire (now extinguished) destroying roof support. The options will clearly depend on the individual mines particular hazards. The focus will now, not only be on the IMT processes, but also those of external agency support – such as QMRS, or whoever the mine nominates as the external support systems for such an event. This will obviously necessitate a different level of co-ordination to the previous exercise and a different range of findings for all concerned. It will not require the evacuation of the affected mine – work should continue largely unaffected. Some mines rescue operation is likely with a similar impact to that of normal training sessions. The greatest impact will be on the mine's IMT who will need to be released to address the "situation".

Both of the exercises will occur within a calendar year, with the aim being to hold Phase 1 prior to this Health and Safety Conference, report the initial findings at the conference with a publicised report to industry shortly after. Then, identifying some level of initiation of the industry based recommendations rather than mine specific recommendations in place at the Phase 2 exercise.

The addition of this second phase is also aimed at reducing the issue of loss of corporate memory – more people exposed to this style of exercise makes for a more robust industry.

Phase 3

Finally the requirement for testing of the mine entry airlock and coupling of the GAG Inertisation unit will occur at a time that is mutually convenient to both the mine and the QMRS. This acknowledges the fact that it may not always be practicable or necessary to instigate these steps in every emergency response. Similarly, it is recognised that fitting these steps in with normal mine downtimes such as main fan outages is more conducive to all parties.

A Challenge for Crinum

It must be stated very clearly at the outset that the Emergency Exercise Management Team (EEMT) had significant difficulty in devising an exercise that would stretch Crinum's systems and retain credibility as a practicable exercise. This was mainly because of the mine's robust ventilation system and the nature of the underground hazards. This is a commendable situation.

The objective of the EEMT was to create a situation of sufficient magnitude that a full mine evacuation was necessary with an integrated response from the mine's Incident Management Team (IMT). This must be to a level of complexity that all personnel are affected to some degree.

Crinum's relevant particulars in brief:

Main Headings - 3 intakes, 2 returns.
Conveyor belt (C Hdg) installed in the centre heading and is segregated from other roads.
Transport roads are predominantly one way – travel inbye using A Hdg, outbye using B Hdg.
The seam exhibits low/medium propensity to spontaneous combustion.
Seam gas is predominantly carbon dioxide at relatively low levels.
Very little timber is used for strata support. It is mainly in the form of steel tendons or bolts with some steel square sets.
Use is made of non-flammable lining of some work areas.

Construction of the Incident

Most major incidents that lead to a co-ordinated response from a mine are generally as a result of a combination of failures as illustrated by the Reason Model. Therefore in simulating the occurrence of an incident each of these factors should be included: Organisational and System Factors, Task and Environmental Conditions, Individual and Team Actions and finally, Absent or Failed Defences.

To this end the following material was reviewed in order to gain an understanding of the mine, relevant existing hazards and potential combinations of use:

- Hazard Management Plans
- Operating Procedures
- Mine Plans
- Ventilation Model
- Operational Layout of the mine
- Incident Records.

The main difficulty in creating a suitable incident at Crinum is that it is unlikely to affect other panels due to the ventilation system. Hence the need to actively enlist all aspect of the above model.

Unfortunately, it is not possible to reveal more of the incident or findings at this stage with the exercise programmed to occur just prior to the conference.

Findings & Recommendations from the Crinum Exercise

Thanks and appreciation is extended to key personnel at Crinum Mine for their assistance and professionalism in conducting this exercise. Specifically: Steve Bullough, Gary McSpadden, Mark McCamley, Peter Baker and Dan Cherry.

Secondly thanks go to the Emergency Exercise Team – particularly Martin Watkinson, Darren Brady and Kirrily Star who carried the bulk of the load; Greg Dalliston, Wayne Hartley, Michael Downs, Peter Baker (NSWMRS), Seamus Devlin, Ron Stothard, Mark Donghi and Bruce McKinnon.

Responding to the Challenge – Crinum's Perspective

Who's Next?

The previous standard for Emergency Exercises is being redrafted, including the indicative schedule for locations of the exercise. One of the issues that hamper the EEMT is the difficulty in accessing Principle Hazard Management Plans, Ventilation Models and Mine Plans for planning purposes. There is obviously an issue of confidentiality to be addressed, however, with the requirement of a second phase to each exercise, it will be critical to obtain sufficient information for this process. Therefore, there will be requests for this information at different times throughout the year as well as an indication of operational status of selected mines.

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Inertisation of Loveridge No.22 Coal Mine

Ray Parkin, Queensland Mines Rescue Service

Introduction

In late February 2003 the Queensland Mines Rescue Service was contacted by Consol Energy Inc. regarding the possibility of using the GAG jet engine in order to inertise their Loveridge No.22 Mine which had been involved in an underground fire since 15th February 2003.

The mine is located near Fairview, West Virginia, which is approximately 135km south-west of Pittsburgh, Pennsylvania in the United States of America (see Figure 1).

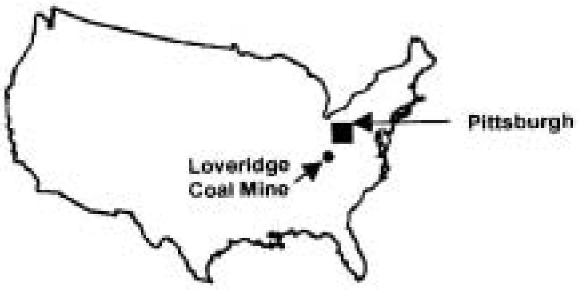

FIGURE 1: Location Map.

The fire started during the middle of the afternoon shift on Friday 13th February 2003. Coal cars loaded with garbage gathered from the operating sections and throughout the mine were brought to the slope bottom in order to be sent out of the mine for dumping.

One of the cars caught fire. The fire was thought to have been extinguished, using several fire extinguishers. Within a short time the fire had flared up again. The decision was made to pull the cars out of the mine to the surface via the slope track.

Whilst undertaking this task several adverse events took place that prevented the cars from being sent out via the slope track. The fire then spread from car to car and subsequently out of control.

Due to its gassy nature, the mine was evacuated and the shafts, boreholes and portal were sealed. Whilst these tasks were being undertaken water was being dumped down the slope. A total of six boreholes were drilled to use as mine atmosphere monitoring locations and to facilitate visual monitoring of mine conditions through a borehole camera.

The Loveridge Mine had a previous fire underground in June 1999, when miners were safely evacuated and the mine was sealed. Some 13 months later In July 2000, under a plan approved by the Mine Safety and Health Administration, mine examination teams re-entered the mine.

The mine was idle from August 2001 to December 2002, when it was re-opened.

In January 2003 limited mine development started with four continuous miners. A longwall was planned to be installed towards the end of 2003.

Consol has had to stand down some 297 employees and, by using the GAG jet engine to inertise the mine, they plan to recover the mine in a fraction of the time that it would normally take for the fire to burn itself out (up to 12 months or more in some cases).

Consol Energy Inc. is the largest producer of high bituminous coal in the USA, and the largest exporter of US coal. It has 20 bituminous coal mining complexes in seven states and one in Australia. In addition the company is one of the largest producers of coal bed methane, with daily gas production of approximately 135 million cubic feet. The company also produces electricity from coal bed methane at a joint venture generating facility in Virginia. Consol Energy's Research and Development Department located in Library, Pa and Morgantown, W.Va is the largest private research organisation in the US devoted exclusively to coal.

History of Inertisation in the Queensland Mines Rescue Service (QMRS)

The history of inertisation in the QMRS originated from recommendations made by the Warden's Inquiry into the accident at Moura No.2 underground mine on Sunday 7th August 1994.

A summary of these recommendations is as follows:

- That research is undertaken in order to determine the most appropriate method of inertisation for Queensland coal mines
- Funds to be made available through the Queensland Government for such a system with appropriately trained people and operating systems. The inertisation system must be readily available, maintained and operated by the Queensland Mines Rescue Service on a fee for service basis

- The successful trials of the jet engine determined the purchase of two GAG units plus the ability to operate both units if required, simultaneously
- The GAG units were purchased in early 1998 at a cost of $1.3 million and handed over to the QMRS for operation and maintenance.

QMRS Background Information

In 1996 the Queensland State Government announced that it was going to withdraw from the funding of mines rescue. It was subsequently agreed that the coal mining industry would assume sole responsibility for both the management and funding of mines rescue.

A public company, Queensland Mines Rescue Service Limited, was established in January 1998 by the industry to take over control and management of mines rescue services for Queensland's coal mining industry. All owners (as defined in the Coal Mining Act 1925) of coal mines in Queensland would become members of QMRS and contribute by way of a levy to fund its operations. A board of four directors would be responsible for the overall direction and management of the company.

In January 1999 new legislation was introduced which enabled QMRS, as an "accredited corporation", to provide mines rescue services.

In broad terms the intent of the new legislation is to provide for the following:

- Ensuring each underground mine owner provides a mines rescue capability for the mine
- Accreditation of corporations to help underground owners provide a mines rescue capability
- Allowing the Minister to fix performance criteria for accredited corporations
- Have sufficient funding to meet the performance criteria
- An inertisation capability.

Issues Involved

The Consol emergency management team (EMT) had been seeking support from QMRS and had subsequently asked for the GAG co-ordinator to assist the management team in identifying the technical aspects of the GAG and its operation. This would assist the EMT in their deliberations and subsequent decision regarding the use of inertisation with the GAG jet engine at the Loveridge mine.

The QMRS agreed to give as much technical support as possible, including sending the GAG co-ordinator to assist the Consol Energy EMT.

However, regarding the potential possibility of sending the GAG to the USA several important questions needed to be answered.

- Does it compromise the inertisation capability in line with the performance criteria?
- What are the ramifications in terms of equipment and personnel if we were to send one GAG unit and two teams to operate the inertisation system?
- What are the insurance issues with such a proposal?
- What are the risks to QMRS?

At this time the GAG had never operated outside Queensland, let alone in USA.

In fact the GAG had only ever been used once in a live fire situation, and that was at the Blair Athol Coal Project in September 1999.

Discussions were held with departmental officers of Natural Resources and Mines regarding the practical and political aspects of sending the GAG to assist Consol Energy.

In order to progress the issue it was decided to conduct a risk assessment by a team comprised of personnel from QMRS, mine operators and union check inspectors.

The risk assessment was to determine if the QMRS would compromise its ability to provide an "inertisation capability" if one of its two GAG units and two teams of operators were to travel to the US.

The unanimous conclusion of the risk assessment team, which comprised 12 people, was in favour provided a number of action points of issues such as availability of equipment and people could be addressed.

The 13 action points were completed by Monday 24th March; however, due to the outbreak of war in Iraq, a travel embargo had been declared by the mining companies. Most mining companies had lifted the travel embargo to the USA by 25th March, paving the way for the team to travel to the US on Thursday 27th March.

The GAG and its associated equipment were air freighted to the US on Saturday 29th March.

The logistics of preparing and organising the 7 tonnes of equipment under priority conditions was significant, and both Australian and American authorities co-operated with QMRS and Consol to achieve a remarkable outcome.

Results

The Inertisation of Loveridge Mine West Virginia, USA from the 27/03/03 to the 20/04/03

A team from the Queensland Mines Rescue Service travelled to the USA on the 27th March 2003 to inertise the Loveridge Mine, which had been on fire since early February 2003. The team arrived from tropical, sunny Queensland to snow-covered Loveridge mine and needed acclimatisation to the cold weather.

A Sequence of Operational Events Follows

On Friday 28th March the team attended a meeting with senior Consol staff regarding the mine plan and application of the GAG at Loveridge mine. The following few days where spent acclimatising to the cold weather conditions.

Loveridge Mine Details
The mine is 335 to 366 metres (1100 to 1200 feet) above sea

level and produces coal from the Pittsburgh No 8 seam using four continuous miners for the development of a longwall panel. The seam thickness is between 1.82 to 2.13 metres (6 to 7 feet) and the bottom of coal elevation range of slope bottom is 94 to 120 metres (380 to 395 feet) above sea level. The slope length is 902 meters (2959 feet). The coal is washed in a coal preparation plant at 1400 tonnes of raw coal per hour.

Figure 2 shows a mine plan of Loveridge Mine.

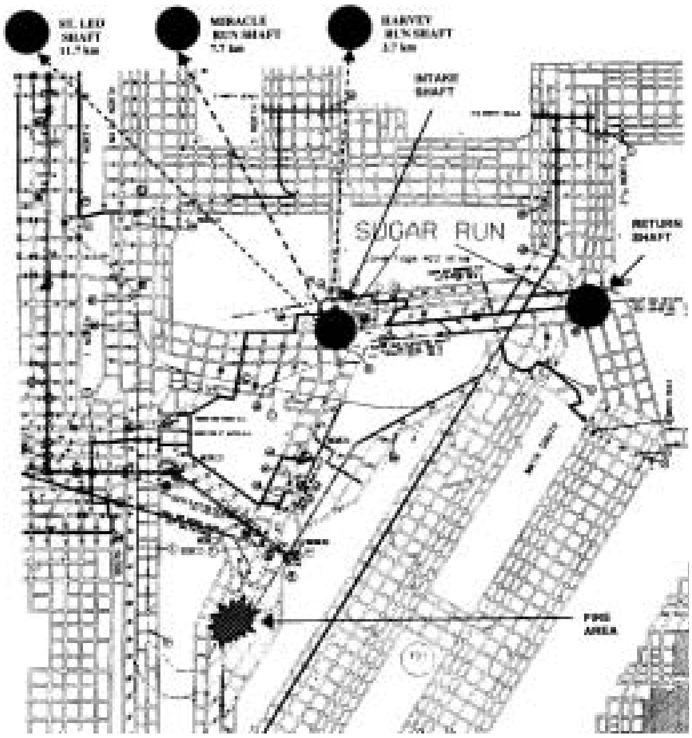

Figure 2: Loveridge Mine Plan.

On Monday 31st March the team travelled to Loveridge Mine to undergo the mine induction programme and to overview the preparations which had been made to connect the GAG to the mine portal (see Figure 3).

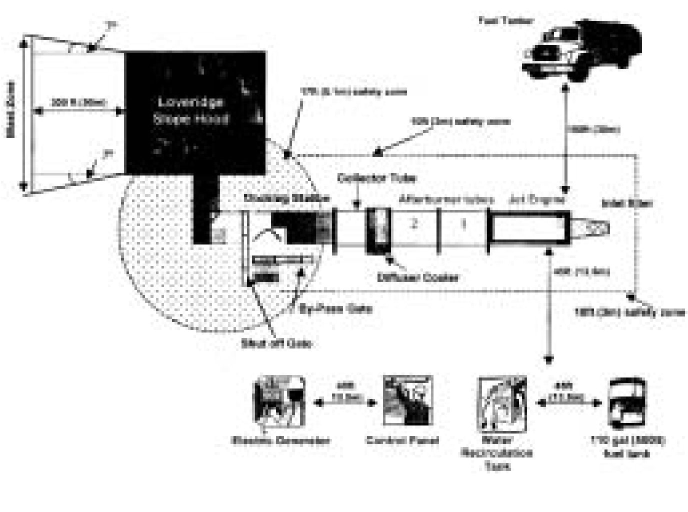

Figure 3: GAG Jet Engine Installation and Blast Zone.

On Tuesday 1st April a risk assessment was conducted between the QMRS team and Consol management to identify the main operational issues for use of the GAG system at Loveridge.

On Wednesday 2nd April the team visited underground operations at Blacksville No.2 Mine in Kuhntown, Pa with the aim of gaining familiarisation of US operations.

On Thursday 3rd April QMRS team members attended a meeting with Consol Management, United Mineworkers of America (UMWA), Mines Safety and Health Administration (MSHA) and the State of West Virginia Department of Mines Health and Safety at Consol's Administration office at Osage. At this meeting the GAG installation was discussed in some detail, including all the safety protocols. At this stage assembly of the GAG would commence on Friday morning 4th April with the expectation that it would be running late Friday afternoon. Discussions were held regarding the re-entry programme once the mine has been completely inertised. It had been previously estimated by the QMRS that the GAG would take approximately three days to completely inertise the mine.

Friday 4th April was the first day of GAG operations; two 5-man teams would operate the GAG on two 12-hour shifts. Assembly of the GAG was started with the day shift team and was completed by late afternoon. The GAG was assembled with very few problems, considering the distance it had travelled. All the appropriate protocols were checked and after all safety checks had been completed the jet was started up not being connected to the afterburner at 5.40pm The jet was exhausting to atmosphere via the exhaust door at 7.45pm The challenge was keeping the tubes cool, necessitating the deployment of additional water sprays to solve this problem.

The GAG started pumping down the mine at approximately 3.30am on Saturday 5th April. The GAG was now working very well; however, leakage of about 20 per cent to 30 per cent was escaping through the belt seal on the surface. This seal was built in order to seal the mine quickly, not for the pressures that would be generated by the GAG.

At 2.30pm the GAG exhaust was bypassed because of the risk of blowing the belt seal on the surface; the backpressure at the time was between 175 to 200mm (7 to 8 inches) of WG.

The GAG was stopped at 3.15pm after approximately 12 hrs of running time for repairs on the seal; the WG had reached 225mm (9 inches) (see Figure 4).

Figure 4: Seal after blow out.

MSHA and Consol personnel were having some difficulty understanding the early gas readings in terms of the inertisation process. It took some time for them to appreciate that the most important reading was the oxygen content of the mine atmosphere, and that the basis of the inertisation process is to reduce the mine oxygen content such that it will not support combustion.

A meeting was held with MSHA and unions regarding the repairs to the seal on the surface. When a mine is sealed due to a fire underground MSHA immediately places a “K“ order on the mine. This means that the parties concerned must agree on every single operation, then a plan has to be drawn up and approved by MSHA before any work can be carried out. Compared to the Australian risk assessment philosophy, it can be a very challenging process.

The repairs to the seal had to be completed without anyone working in the “Blast Zone“ (see Figure 3).

A permit is issued for each step of the recovery operations from the “MSHA Command Centre“, which was located at the entrance to the mine.

On Sunday 6th April the repairs to the seal on the surface were completed and the GAG commenced at 4.00am; WG was between 163 and 175mm (6.5 and 7 inches).

Discussions between MSHA and Consol were held in regard to relieving the pressure on the ventilation shaft at Harvey Run in order to reduce the backpressure on the jet engine. This was agreed to by the Command Centre.

On Monday 7th April, the fourth day of operations, the GAG stopped after approximately 43 hours of operation due to a problem with the fuel pump. The fuel pump was found to be defective; it was decided to connect the fuel line from the fuel tank, which was situated on a hill overlooking the GAG, directly to the jet engine under gravity. The GAG was fed fuel at pressure of 250Pa (10 psi). This was possible because the GAG engine pressurises its own fuel to the afterburner jets. A pressure relief valve was connected for the protection of the system. At the same time GAG maintenance was carried out, which included minor cleaning of carbon at the bottom of the afterburner rings. It was decided that whilst this work was being undertaken on the GAG, the seal on the surface would undergo further major repairs at the same time. The seal was injected with Rocklock.

In order to further relieve the GAG, suction was applied to borehole No.27 at 5.00pm, exhausting 26 cubic metres per minute (see Figure 5).

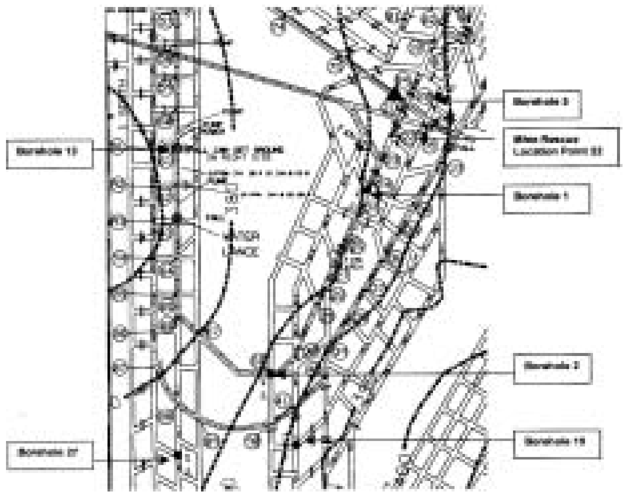

Figure 5: Sugar Run Slope and Fire Area.

GAG pumping operations started at 4.00pm. The shift sequence started at 9.00am with seven team members on the day shift and then 9.00pm with six team members on night shift. All team members on both shifts were given the option of one person taking a rest day on each shift on rotation.

On Tuesday 8th April the GAG was stopped at 2.00pm due to a hot spot on the afterburner. On investigation it was found that a build-up of carbon had occurred, which caused the afterburner rings to be distorted. New afterburner rings were required. The GAG was restarted at 4.00pm.

Hot gases were reported at St Leo shaft, which is the most westerly shaft at the mine and is approximately 14km from the GAG site, which means that we had established a circuit approximately 14km long. This was achieved after approximately 65 hours of GAG operations.

On Wednesday 9th April, the sixth day of operations, the GAG readings were as follows:

WG 87.5mm (3.5 inches), revs 8000, oxygen 4.8 per cent. The hot spot on the afterburner was moving around due to the build-up of carbon and distortion of the afterburner ring.

The GAG was stopped for maintenance after approximately 84 hours of running time.

The afterburner ring was found to be broken and the bottom area of the rings was solid with carbon (see Figure 6). New afterburner rings were fitted. Contractors using 309 stainless steel from plans produced by Consol engineers manufactured the afterburner rings. The GAG was restarted at 6.00pm. It was estimated that the fuel consumption of the GAG was 1827 litres/hour.

Figure 6

On Thursday 10th April, the seventh day of operations, the GAG was stopped for further maintenance. Engine carbon deposits still persisted. The inner afterburner ring was replaced and the GAG was started up again at 3.30am.

During the next maintenance it was necessary to change the engine oil from Shell to BP because we had exhausted the supply of the appropriate Shell turbine oil.

It was decided to stay with with the BP product and flush the whole system out in order to ensure that the best possible result for the running of the jet engine could be achieved.

MSHA produced Cowards Triangle graphs showing that at 11.00am, after approximately 102 hours of GAG pumping time, the St Leo intake and return shaft contained non explosive mixtures, which demonstrated that the whole mine was completely inertised. This was an historic moment for the GAG operations. A mine the size of Loveridge had been completely inertised and now recovery operations could commence (see Figures 7 and 8).

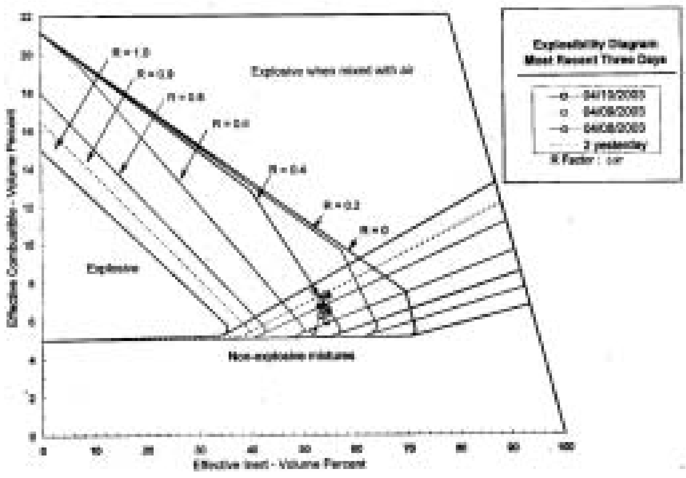

Figure 7: Loveridge Mine – St Leo Return.

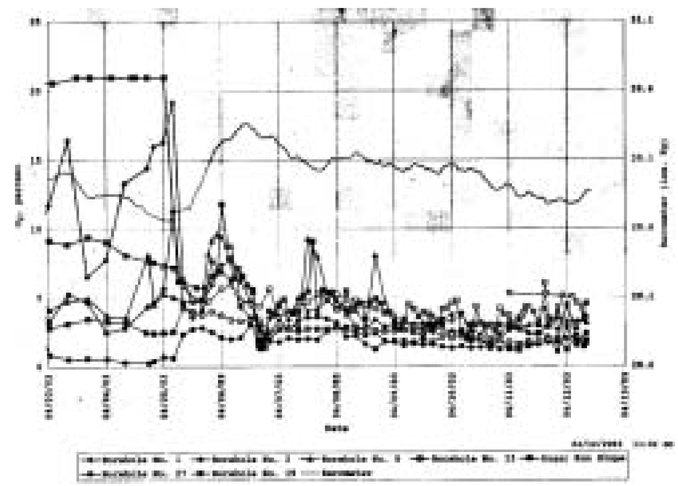
Figure 8: Loveridge Mine Oxygen.

The borehole readings at 11.00am on 10th April for methane, carbon dioxide and carbon monoxide were as follows:

	CH_4 %	CO_2 %	CO ppm
Borehole 1	0.1	12.1	4200
Borehole 2	0.6	14.4	5300
Borehole 5	0.2	14.0	4100
Borehole 13	0.9	13.7	1500
Borehole 19	0.7	14.1	2400
Borehole 27	0.8	13.3	1700

Following discussions with MSHA it was agreed that the natural ventilating pressure and the barometer played a huge part in the problems associated with the high backpressure during the early part of the inertisation process. It was also agreed that roof falls underground may be a part of the backpressure problem.

Consol could now begin recovery operations, and in this regard they started to install a submersible pump in Sugar Run Intake shaft to pump water from the bottom of the shaft so as to get it operable again and allow rescue teams access to the mine. The GAG was stopped at 3.10pm for further maintenance and restarted at 6.40pm.

On Friday 11th April, the eighth day of operations, the GAG was stopped for maintenance. A cracked afterburner ring was replaced and carbon deposits removed. It was planned to flush the engine oil when the jet was restarted at the next service. The GAG was running at 8000 revs at 150mm WG. Consol's people were having great difficulty getting the submersible pump down the shaft. The video camera found that the pump was lodged at right angles in the shaft just above the water line. It was further established that all borehole samples were being taken at the bottom of the coal seam.

On Saturday 12th April it was observed that when the GAG was stopped, Sugar Run Intake out-gassed; and when the GAG started, the Intake in-gassed again. So when rescue people were working on the shaft it was important that the GAG was kept running.

GAG readings were 8000 revs, 150mm WG and oxygen 6.1 per cent. Consol was still having problems with the submersible pump. St Leo shaft was open and out-gassing at 11.15am. Harvey shaft was also open.

The GAG by-passing gate was opened slightly in order to reduce the backpressure; WG dropped 50mm to 125mm WG. GAG stopped for maintenance at 3.30pm.

At this stage the afterburner had some slight distortion. It was important to maximise the continuous running time to complete the inertisation process.

The plan of the next stage of the programme was as follows:

1 Pump water out of Sugar Run (SR) elevator shaft
2 Complete repair work in order to operate the SR elevator shaft
3 Final service on the GAG
4 Start St Leo fan
5 Start Miracle Run fan
6 Re-enter the mine via SR elevator shaft with rescue personnel.

On Sunday 13th April, the tenth day of operations, the GAG was started with the door cracked, backpressure 100mm WG. The backpressure had dropped to 50mm; the door was tightened to achieve 125mm WG. We had to ensure that the backpressure was kept at 125mm WG so that when starting the fans we had an appropriate safety factor to guard against any negative pressure on the jet engine. The St Leo fan started at 4.05pm and the Miracle fan started at 4.08pm, with no effect on the GAG backpressure.

The Harvey Run fan was started at 10.45pm and was stopped at 1.00am due to increased backpressure on the GAG. It should have had the opposite effect.

On Monday 14th April, the eleventh day of operations, the GAG was stopped for maintenance and re-started at 8.20am. Pumping water out of the elevator shaft was completed and an examination of the elevator shaft commenced. Rescue teams enter the SR elevator shaft to start the re-entry programme. Two rescue teams enter the mine at 10.30pm; they found good visibility with a temperature of 90ºF.

On Tuesday 15th April, the twelfth day of operations, the GAG was stopped for maintenance; one afterburner ring was changed and the engine ran much better. Rescue teams were establishing a new fresh air base and they were also finding quite a few falls of ground, which was causing them to make detours to get to the fire area. The GAG readings were 9300 revs, 62mm of WG, 5.5 per cent oxygen.

On Wednesday 16th April rescue teams found a fall inbye the dump station at the bottom of the slope, which limited their options regarding access to the fire area.

On Thursday 17th April, the fourteenth day of operations, water was being pumped from borehole 13 in order to gain access to the fire area (see Figure 5). Water was now being pumped from the second and third pumps. The mine had been inertised for some days now and the plan was to shut down the GAG permanently at midday on Friday 18th April. This date had been extended from Wednesday 16th. Consol's Chief Operating Officer – Coal asked if the GAG could stay for a further two days. This was agreed to, resulting in the GAG being dismantled at midday on Sunday 20th April.

On Friday 18th April, the fifteenth day of operations, the GAG was stopped at 2.30pm and put on standby after approximately 240 hours running time (time pumping into the mine).

Consol personnel continued to pump water from the fire area so that it could be sealed off. The rescue teams had found evidence of a fire in the roadways south of the coal and materials slope, which were full of water approximately one metre deep. The fire was active in the roof of the coal seam.

Consol personnel started to pump nitrogen down No.1 and No.2 boreholes (see Figure 5) in order to cool the area down. When the water had been pumped out they were in a position to seal the roads south of the coal and materials slope, and still allow access for coal and materials transport via the slope without having to drive an additional roadway for access.

On Saturday 19th April, the sixteenth day of operations, the GAG was on standby until noon on Sunday 20th April. Consol personnel continued to pump nitrogen down boreholes No.1 and No.2 at 34 cubic meters per min; the fire area was cooling down. Mine rescue teams were working on a fall at location 22 (see Figure 5). The temperature had reduced to 120ºF.

Eleven rescue teams were working on the recovery operations at Loveridge Mine. They were working on a 2 hour change-over. The rescue teams were waiting for the fire area to cool down before they could advance towards the fire area.

The gate door inbye of the jet engine was opened for the slope to exhaust (outgas) to atmosphere. An auxiliary fan was hooked up to the door ready to exhaust in the event of the slope starting to ingas. The rescue teams were in the process of establishing a route underground in order to get materials to the sealing sites.

On Sunday 20th April, the seventeenth and last day of operations, nitrogen continued to be pumped down boreholes No.1 and No.2. Borehole readings were being maintained at low oxygen and CH4.The rescue teams now had control of the fire area.

It was suggested by QMRS and some Consol personnel that preparations should be made to seal the area so that the fire area could be flooded. The contours favoured this approach, and there would still be access to the coal transport and supply slope. This option was being discussed when we left the mine at midday. The temperature in the rescue working areas was down to 90ºF.

At 10.00am QMRS started to dismantle the GAG, and this was completed by 1.00pm.

Fact Sheet on the GAG-3A Jet Engine

- The jet engine weighs about 700kg and fully assembled it is about 12 metres long, weighing a total of 2.5 tonnes. The total weight including support equipment is 6.8 tonnes. It is carried by truck and takes about three hours to assemble
- A generator is used for all auxiliary electrical power such as water pumping requirements, electrical gas monitoring and area lighting
- In use the de-thrusted jet engine draws in and compresses air in which fuel is burned in its turbine chamber to power the unit. The air then passes to the afterburner where additional fuel is burned to reduce the oxygen content to less than 1 per cent. Hot gases then pass into water-cooled delivery tubes and finally water is injected into the gas stream, which vapourises
- The unit produces between 25 and 30 cubic metres/second of water-saturated misted gases at a temperature of 81 to 85ºC, which equates to about 10 cubic metres/second of dry gas after condensation of water content
- The unit requires six people for the start up and shut down sequence and three people to maintain operations
- Fuel burn is about 1600 litres/hour – Jet A1 fuel
- Engine revolutions running idle are 7500 to about 10000 revolutions/minute
- For cooling and water injection a minimum water supply is about 11 litres/second for closed cycle operations
- The GAG was developed in Poland and has been used in Polish and Czech mines to good effect. It has also been used in South African gold mines for the last six to seven years to control fires in timbered stopes
- GAG was first used at Blair Athol mine in central Queensland in September 1999 when it successfully extinguished a large fire
- Products of combustion are nitrogen, carbon dioxide, water vapour and trace elements. A typical gas analysis is as follows:
  - 85 per cent nitrogen
  - 13 per cent carbon dioxide
  - 1.6 per cent oxygen
  - 0.4 per cent carbon monoxide.

Conclusion

- The inertisation of Loveridge Mine was a successful venture in which two countries co-operated to further the advancement of mining technology
- It was a collaborative effort of Consol Energy, the Queensland Mines Rescue Service, the National Institute for Occupational Safety and Health, the US Department of Energy, the United Mine Workers of America and the Mines Safety and Health Administration
- On 10th April 2003, after approximately six days and 102 hours of GAG pumping time, graphs produced by MSHA of the Cowards Triangle showed that from the slope entrance to the most westerly shaft at St Leo, a distance of approximately 14km, the mine was completely inertised. In other words, no explosive mixtures existed at any of the monitoring points in the mine
- To our knowledge this is the first time that one GAG jet engine has operated for some 240 hours over a period of 13 days
- When the GAG first started operations the MSHA and Consol personnel were having some difficulty understanding the gas readings from the monitoring points (boreholes) due to the complexities of the inertisation system. It took some time for them to understand that the main purpose of the inertisation process was to reduce the mine oxygen content such that it would not support combustion
- The effects of the barometer, the mine natural ventilating pressure and roof falls underground had considerable influence on the backpressure that the GAG had to overcome in order to operate effectively
- During the period of operation the backpressure on the GAG was such that it created major issues of maintenance of the afterburner rings. Towards the conclusion of the exercise the afterburner was somewhat distorted due to the build-up of carbon deposits. We did not have a spare afterburner and for the safety of the initial recovery operations we just had to keep the unit operable
- Compared to the Queensland coal mining industry's risk assessment philosophy it may be considered that the way that MSHA controls every operation can be a very time-consuming and challenging process
- The Australian team members carried out their duties in a very professional manner; they were good ambassadors for both their country and indeed the Queensland Mines Rescue Service during the GAG operations at Loveridge
- Finally, it would be remiss of me not to mention the wonderful hospitality and comradeship afforded to the Australian team by Consol Energy personnel during the inertisation process.

Recommendations

- That hydraulic doors be fitted to the sliding gates, which control the airflow on the GAG exhaust
- During similar operations it would be advantageous to have an additional afterburner and afterburner rings.

Acknowledgements

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Real Time Integrated Mine Ventilation Monitoring

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Abstract

Software has been developed to link real time information generated by underground mine ventilation airflow monitoring sensors into a network simulation program to undertake network simulations and allow interpretation of key system data and operational changes. Results are used in the development of a computerised monitoring and simulation system to provide immediate or real time data on air behaviour within each branch within an underground mine ventilation network through linking of sensors to the ventilation network simulation software. The outcome of the project is an online system which can report changes in the mine ventilation system, allow causes of changes to be isolated and rectified, improve balancing of available air throughout the mine, allow improved approaches to regulator setting and dispense with much of the labour used for underground ventilation measurement. The main work activities involved in the research program have involved examination and modelling of regulators used in two Queensland mining (coal and metalliferous) environments, software modification and considerable mine site testing and optimising activities. The mathematical modelling of airflow through operating mine regulators was an important part of the project and this aspect is discussed.

Introduction

There is a move world wide to remote or telemetric monitoring of mine atmosphere conditions. Robust, suitable and intrinsically safe instruments are available for measurement of, for instance, gas concentrations, air velocity and air pressure. These are often tied to extensive mine monitoring and communication systems.

One approach to establishing air quantity through a ventilation branch is through measurement of differential pressure across an opening or regulator. Mathematical relationships are available to relate (with some qualification) pressure drop and quantity through a regulator orifice placed symmetrically in a round flow conduit. However these can, at best, only be used to approximate mine regulator behaviour due to:

- The irregularity of mine regulators in shape and symmetry and their positioning in normally roughly square or rectangular mine airways
- The construction of the mine regulator opening which may result from, for instance, the operation of louvres, a sliding door, window or curtain or placement of drop boards, and
- Uncontrolled air leakage through the regulator or adjacent bulkhead.

The study briefly describes efforts to characterise or mathematically model regulators. It then describes how this information is used in the development of a computerised monitoring and simulation system to provide immediate or real time information on each branch within an underground mine ventilation network through linking of sensors to the ventilation network simulation software. Software has been developed to link real time information generated by mine ventilation monitoring sensors into the network program to undertake network simulations and allow interpretation of key system data and operational changes.

The outcome of the project is an online system which can report changes in the mine ventilation system, allow causes of changes to be isolated and rectified and improve balancing of available air throughout the mine, It is envisaged that in time the real time model will be an integral part of an online mine wide planning, monitoring and control software platform that will be updated continuously along with the mine plan. The main steps involved in examination and modelling of regulators, software modification and considerable mine site testing and optimising activities are described.

Theory of Regulators

A regulator is an artificial resistance (in the form of shock loss) introduced into an airway to control airflow. A regulator can be described as a large thin plate installed in a fluid conduit with an orifice. When a difference in pressure exists between the two sides fluid flows in the pattern shown in Figure 1. On the low pressure side the fluid issues as a converging jet in line with the centre of the orifice. The jet converges to its smallest area at a distance of about half the orifice diameter (Le Roux, 1990). This area is called the "vena contracta" (A_c at Fig. 1). The ratio between vena contracta and orifice area is the "coefficient of contraction", C_c (A_c/A_r at Fig. 1).

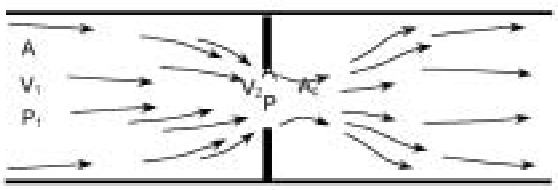


Figure 1: Airflow pattern through an orifice (after Burrows et al, 1989).

McElroy (1935) found that the C_c value is a relation between the ratio of the orifice and airway cross sectional area, N (A_r/A at Fig. 1), and Z, which is an empirical factor designated as the contraction factor, which is expressed as:

$$C_c = \sqrt{\frac{1}{Z - ZN^2 + N^2}} \quad (1)$$

Values of Z vary according to the edge shape of the orifice. Since most regulators are square edged, a Z value of 2.5 is most commonly used in calculating C_c. Bernoulli's equation can be applied to both sides of the orifice as shown in Figure 1 in order to calculate the velocity and hence the airflow quantity.

A correction must be made for the contraction of the jet at the vena contracta. Since the orifice is larger than the vena contracta, orifice velocity is lower than in the vena contracta. The velocity equated based on Bernoulli's equations is the velocity at the vena contracta. Therefore, the velocity at the orifice can be obtained with the following equation:

$$V_2 = C_c\sqrt{\frac{2\Delta P_s}{\rho}}\frac{1}{\sqrt{1-N^2}} \quad (2)$$

where C_c is the coefficient of contraction, as described before. Since airflow quantity through regulator $Q = V_2A_r$, it follows that:

$$Q = C_c\sqrt{\frac{2\Delta P_s}{\rho}}\frac{1}{\sqrt{1-N^2}}A_r \quad (3)$$

where A_r is orifice opening area in m^2.

Field Tests of Regulations

Field tests on several types of regulators were conducted at various underground metalliferous and coal mines. Initially verification of air behaviour in flow through regulators was investigated. Parameters measured were airflow quantity and pressure drop across regulator. From pressure drop measurements, airflow quantity through regulators can be calculated with Equation 3. Results of this calculation can be compared with measured values and the reasons for significant differences investigated.

Drop Board Regulator Tests

The regulator test at the University of Queensland Experimental Mine (UQEM) is the drop board type as shown in Figure 2. Details of the tests and equations derived to account for leakage during measurements were described and discussed by Wu et al (2003) and Gillies et al (2002).

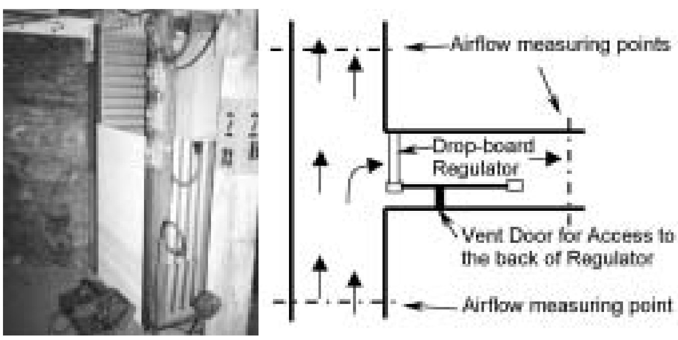


Figure 2: Drop board regulator tested at UQEM.

The relationship between the regulator opening area and total resistance can be derived as shown in Figure 3. Based on this, pressure and airflow quantity relationships can be calculated from mine regulator impedance characteristic curves. These can be drawn for different mine configurations as shown in Figure 4. The three curves shown illustrate relationships for one, three and five boards removed from the regulator.

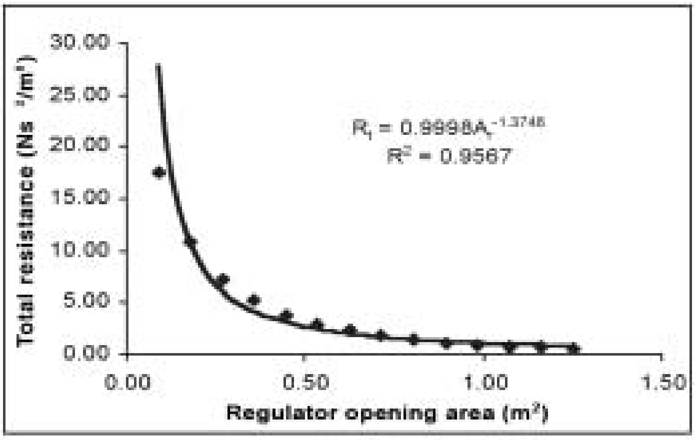


Figure 3: Relationship between new total resistance and regulator opening area.

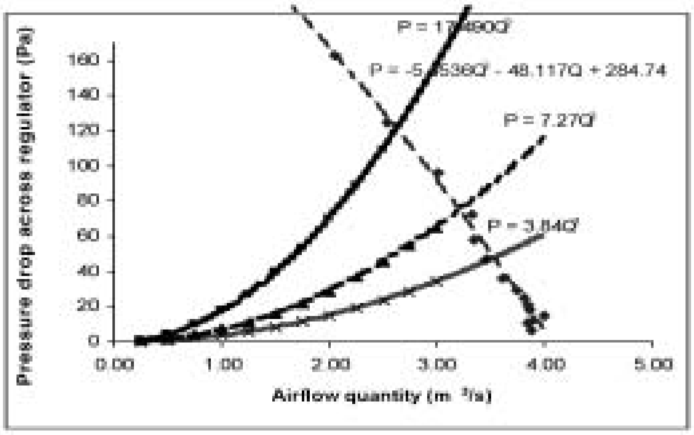


Figure 4: Drop board regulator characteristic curves.

C-section Regulator Tests

Similar tests were conducted on Drop Board style C-section regulators. Figure 5 shows a photographic view and the engineering drawing of a C-section regulator used by an Australian mine. The regulators were installed in either half or full sizes depending on the magnitude of the airflow regulation requirements and the locations.

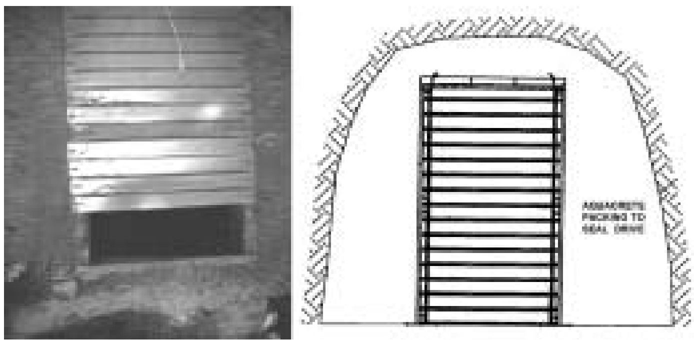


Figure 5: Photographic views and engineering drawing of a half size C-section regulator.

A half size ventilation regulator may consist of up to a total of 16 C-section galvanised steel boards, which are secured with humpback split pins to the frame structure. The full sized version is two of these regulator frames placed side by side. The frame structure is secured in place using rock bolts to the concrete floor base. Packing is used to seal the bulkhead around the regulator frame structure. Dimensions of each C-section board are 1.65 m in width and 0.2 m in height. The maximum opening area of a half size C-section regulator is 5.28 m^2.

Several test series were also undertaken to verify the relationship between the equivalent total regulator resistance, R_t, and equivalent opening areas, A_r at various locations at the same mine. Figure 6 shows the calculated relationships between Rt and A_r for the C-section regulators. It can be seen that the relationships are similar to the relationship established from the drop board regulator tests.

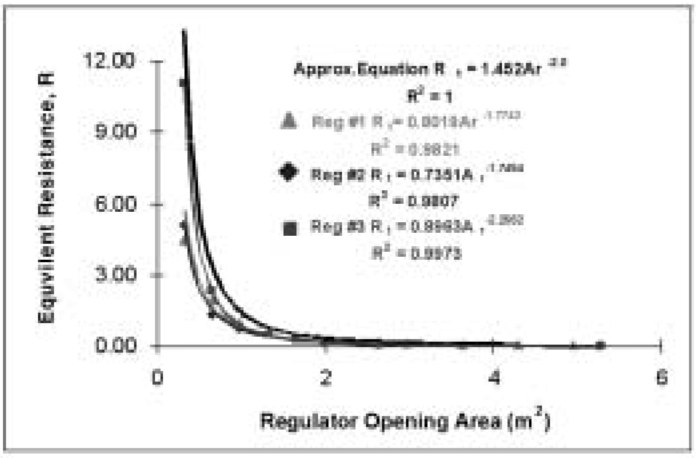


Figure 6: Relationship between R_t and A_r for C-section regulators.

In Figure 6, a theoretical relationship between the equivalent resistance and the opening area of a regulator similar to the approximation equation proposed by Le Roux (1990) was also included with assumptions made to account for the general mining conditions, for example, C_c = 0.64 and $\sqrt{(1-N^2)}$ = 1. Therefore a value of 1.1 was suggested to replace these terms and R_t can be calculated from the following equation at standard air density of 1.2 kg/m^3.

$$R_t = 1.452 A_r^{-2.0} \quad (4)$$

In Figure 6, it can be seen that the equivalent total resistance calculated from the tests was lower than the theoretical regulator resistance. As mentioned before, the equivalent total regulator resistance also takes into account resistances of the leakage paths which parallel air paths through the regulator opening. It is expected that the values of R_t will be lower than the regulator resistance itself.

Louvre Regulator Tests

Tests were carried out on louvre type regulators. This type of regulator is popular in Australian coal mines and an example is shown in Figure 7. Generally a double vehicle door design has louvres placed within panels of both doors. The louvre blades can be adjusted to various angles to control airflow. In this test both left and right doors could be set at nine positions. Tests were undertaken both by holding one side fixed and varying the other and by varying both sides. Relationships between resistance and the equivalent opening areas are shown in Figure 8.

Figure 7: An example of a louvre regulator.

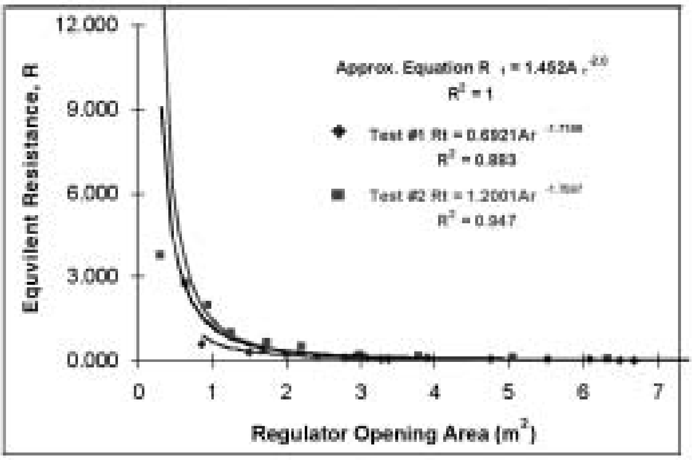


Figure 8: Relationship between resistance and equivalent opening area for louvre regulator.

It would appear that both aspects follow a similar relationship to that observed for the drop board or C-section regulators tested. There is no doubt that the resistance values increased as the equivalent opening areas decreased. However, it is suspected that due to the nature of fluid flow through louvre blade settings, the relationship between the resistance and equivalent opening areas is a more complex than drop board flow behaviour. A literature review on louvre regulators indicated that only limited research had been conducted on louvre flow behaviour.

Roller Door Regulator Tests

Use of a roller door as a ventilation regulator was examined. Adjustment of the height of this door is undertaken via an automated control system. There is very little information on the use of roller doors as ventilation regulators and on the automation of such a system.

For this study, a roller door was installed for trial purpose as shown in Figure 9. Basically the roller door works like a Venetian blind, that is the lifting belt (made from sling material) is attached at the bottom corners of the door leaf and runs up inside the side guides to the drive assembly at the top. As the drive winds the belt, it lifts the bottom beam and each successive horizontal aluminium beam stacks on the top causing the vinyl coated fabric to billow out on the both sides as the air is expelled.

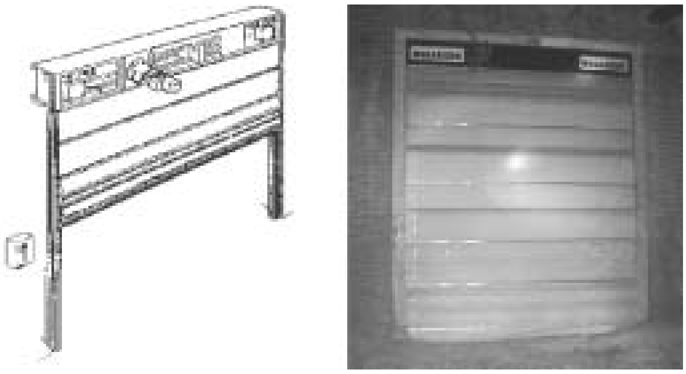
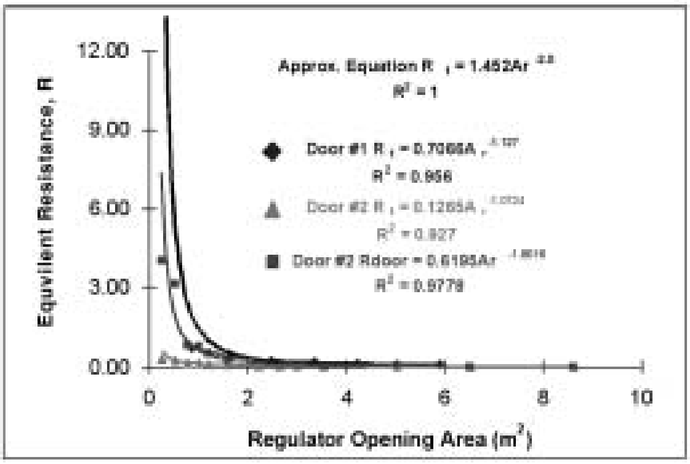


Figure 9: Schematic and photographic views of a roller door regulator.

Several regulator characteristic tests were carried out to establish the relationship between Rt and A. The following figure shows the relationship between Rt and Ar for roller door tested. It should be noted that the air quantity and pressure was very low during the tests. Therefore, the calculation of equivalent resistance from measurements was difficult.

Also as one of the tests was conducted when the roller door was installed without a proper bulkhead built around it, a temporary brattice was erected to stop the airflows around the door. For this reason the leakage was substantial which means the equivalent resistance of the roller door regulator structure tested was much lower. As measurement was taken with the door fully closed it was possible to work out the equivalent resistance of the leakage paths around the door structure and then back calculate the resistance of the roller door only, Rdoor, without the leakage paths as shown in the Figure 10. It can be seen that it gives a much better comparison with the theoretical relationship between R_t and A_r.

Figure 10: R_t vs. A_r for Roller Door regulator tested.



It is proposed that further tests should be undertaken under higher air pressure and quantity conditions with a proper bulkhead built around the roller door regulator. In summary, the behaviours of various types of regulators examined can be described by the equations shown in the following table.

Table 1: Summary of equations for various regulators tested.

Type of Regulator	***Regulator Equations****
Drop Boards	$R_t = 0.9998A_r^{-1.3746}$
C-sections	$R_t = 0.7685A_r^{-1.7619}$
Louvre	$R_t = 1.2009A_r^{-1.7597}$
Roller Door	$R_t = 0.6195A_r^{-1.8016}$

** Some equations derived from averaged results of multiple regulator tests.*

Real Time Mine Ventilation System

The aim of this mine ventilation research was to develop a computerised monitoring system to provide immediate or real time simulated information on each branch within an underground ventilation network. The system measures airflow or air pressure changes in selected ventilation branches and simulate flows through all other branches. This new approach to ventilation provides improved understanding of airflows through all mine sections. The popular ventilation simulation modelling program Ventsim has been used as a simulation engine within the system. This software has been altered by the program author, Mr Craig Stewart to accept real time information generated by underground mine ventilation monitoring sensors, undertake network simulations and interpret key system data and operational changes. Once the simulation program has updated readings it can remodel the whole mine system, report the flows in all branches and compare individual branch readings with expected values.

Initially, the UQEM was used to test the integration of a telemetry system into the Ventsim network analysis environment. The mine airflow monitoring system consisted of one El-Equip "Flosonic" and two vortex shedding Sieger BA5 air velocity sensors. The Flosonic air velocity sensor is an ultrasonic anemometer measuring the average air velocity value across a drift (Casten et al, 1995 & McDaniel et al, 1999). The aim of this testing was to use the system to monitor changing ventilation conditions, to establish airflow characteristics within the UQEM and to observe the resimulated network results. Details of the integration of the UQEM real time ventilation monitoring system including Ventsim modification have been described by Gillies et al (2000).

Real Time Ventsim Modifications

Real time monitoring and simulation functions have been built into a recent version of the original Ventsim network simulation program. To run network simulation with real time data input, real time sensors installed in the ventilation network need to be numbered initially. Details of the real time sensors was input and edited in the Remote Station database as shown in Figure 11.

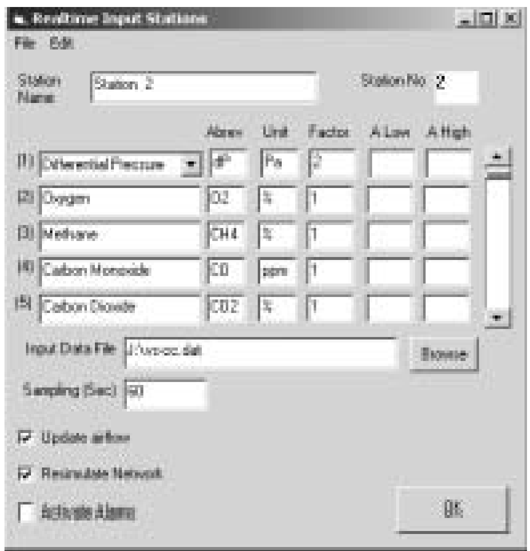


Figure 11: Example of information required for real-time input stations.

The Remote Station database consists of a list of remote locations and their detailed information such as type of sensors (up to five sensors for each station); unit of real time data, scale factor, alarm levels (low and high) for each sensors; location of real time input data file; sampling interval. Users have the options to select whether they want the real time Ventsim to update airflow values, re-simulate network and activate alarm or not. Up to 50 different remote stations may be stored within the current version of real time Ventsim.

The real time data from underground remote stations must be made available to Ventsim through a text file with a special format that can be recognised by Ventsim and stored in the directory as specified in the Input Data File path. A specific tab delineated text file format is required by real time Ventsim as follows.

Table 2: Specific data format required by real time Ventsim.

11 Procedure Formal Training Stringent Testing Level 2	16 Procedure Formal Training Stringent Testing Level 2	20 Procedure SWI Formal Training Stringent Testing Level 1	23 Procedure SWI Formal Training Stringent Testing Level 1	25 Procedure SWI Formal Training Stringent Testing Level 1

Once the details of each remote station are stored in the real time Ventsim, a remote station number needs to be selected in the Airway Edit window as shown in the following figure for each airway containing real time sensors. If in a particular airway the remote station is selected all remote sensors' data eg. air velocity, quantity, differential pressure and various gas levels will be available to Ventsim for display or for network simulation purposes. Once all airways with remote stations have been edited, the network can be simulated with real time data.

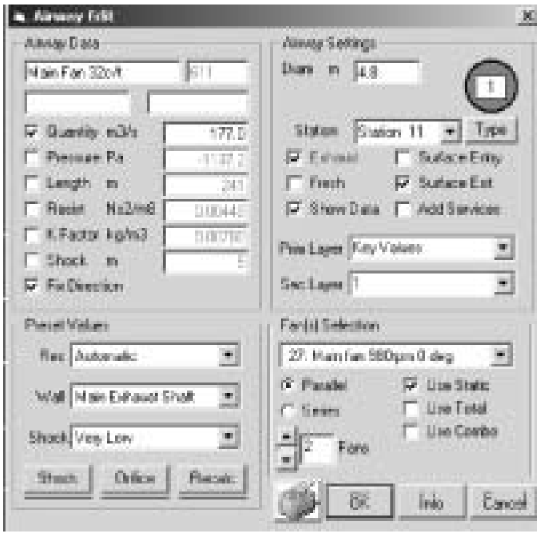


Figure 12: Airway Edit Windows with Remote Station Selection.

Trial at Capcoal Central Colliery

Capcoal's Central Colliery located in the Bowen Basin was the first modern underground longwall operation in Queensland. Central colliery has an annual production of 2.5 million tonnes per year (mtpy). Major ventilation changes were undertaken at Central Colliery in 2000.

Longwall operations at the colliery had spanned over 16 years before these ventilation changes were made. Before the changes, there were two main fans on the top of the upcast shaft near the transportation drift. In addition, the mine has fans on top of two bleeder raises at the back of longwall panels on both sides of the pit primarily for gas (methane) management. Changes to the main ventilating system was made including downcast air via the drifts and the original upcast shaft near portal and then upcast return air through a raise bored shaft at 32 cut through (ct) with two refurbished main fans from nearby Southern Colliery.

As delivering the required air quantities to the operating faces was becoming very difficult due to the high mine resistance, it was determined that the ventilation system at Central need to be closely monitored with the installations of louvre type regulators and real time sensors at strategic locations throughout the mine. Various airflow sensors were investigated initially for the project. Certain problems have been identified with air velocity sensors using vane anemometers, thermal mass cooling, and vortex shedding techniques. As all these sensors measure spot air velocity instead of average air velocity. They are found to be difficult to re-calibrate to variable airflow requirements in operating mines and the output signal has a tendency to "wander away" immediately following re-calibration (McDaniel, et al, 1999). The unreliability and lack of repeatability of these instruments will hamper the continued development and use of these types of sensors in mining industry. It was determined to install differential pressure sensors across regulators to measure the pressure drop induced by the shock loss.

A total of eight underground remote monitoring stations using intrinsic safe differential pressure sensors have been installed for the trial at Central Colliery. An additional four remote stations with monitoring data for surface fans were also included in the system. Details of these monitoring stations and their status are shown in the following table. In Capcoal Central Colliery, real time underground monitoring data are displayed on their mine control and monitoring system – Microview. This information is displayed in a purpose made page as shown in the Figure 13.

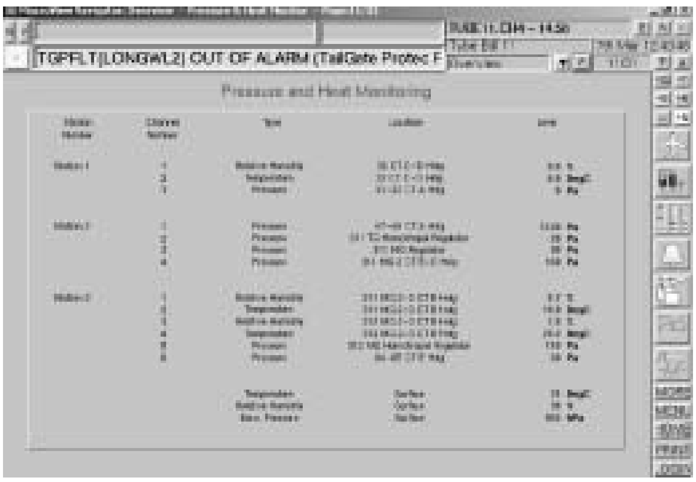


Figure 13: Pressure Monitoring Display at Central Colliery Microview System.

Table 2: Details of Remote Monitoring Stations Information at Central Colliery.

Stations	Locations	Type of Data	Remarks
1	31-32ct A Heading	Differential Pressure	Not reading
2	47-48ct A Heading	Differential Pressure	Will be moved soon
3	311 TG Homotropal regulator	Differential Pressure	Fully opened
4	311 MG regulator	Differential Pressure	
5	311 MG 2ct B-C Heading	Differential Pressure	
6	312 MG 2ct B-C Heading	Differential Pressure	
7	64-65ct E Heading	Differential Pressure	
8	Surface Station	Barometric Pressure	Not for simulation
9	Borehole Fan 311	Air Quantity	Sensor faulty
10	Borehole Fan 311	Differential Pressure	Sensor faulty
11	Main Fans	Air Quantity	
12	Main Fans	Differential Pressure	

An example display of the Capcoal Central Colliery real time Ventsim model with "live" data is as shown in Figure 14. Due to the site operational constraints, currently, only five real time sensors have been included in the Capcoal Central Colliery's real time Ventsim model. However, during the trial it was found that the system has the ability to update the mine ventilation network model and keep this mine planning tool current. Mine ventilation models are normally static simulation models that are accurate when calibrated after a mine ventilation survey. Even with care in frequent updating, models will tend to lose accuracy. The real time approach allows the model to be seen as a dynamic entity that can be tested for its accuracy at any time without the effort of undertaking a full ventilation survey.

In a typical coal mine operation, any ventilation change must be authorised before the change is made. Alternative options are evaluated through computer network simulation or manual calculations in the planning phases. Once the " best achievable" alternative is determined, authorisation is gained and necessary adjustments to some of the system regulators made.

Underground ventilation measurements may at some time be conducted to verify the effects of the change.

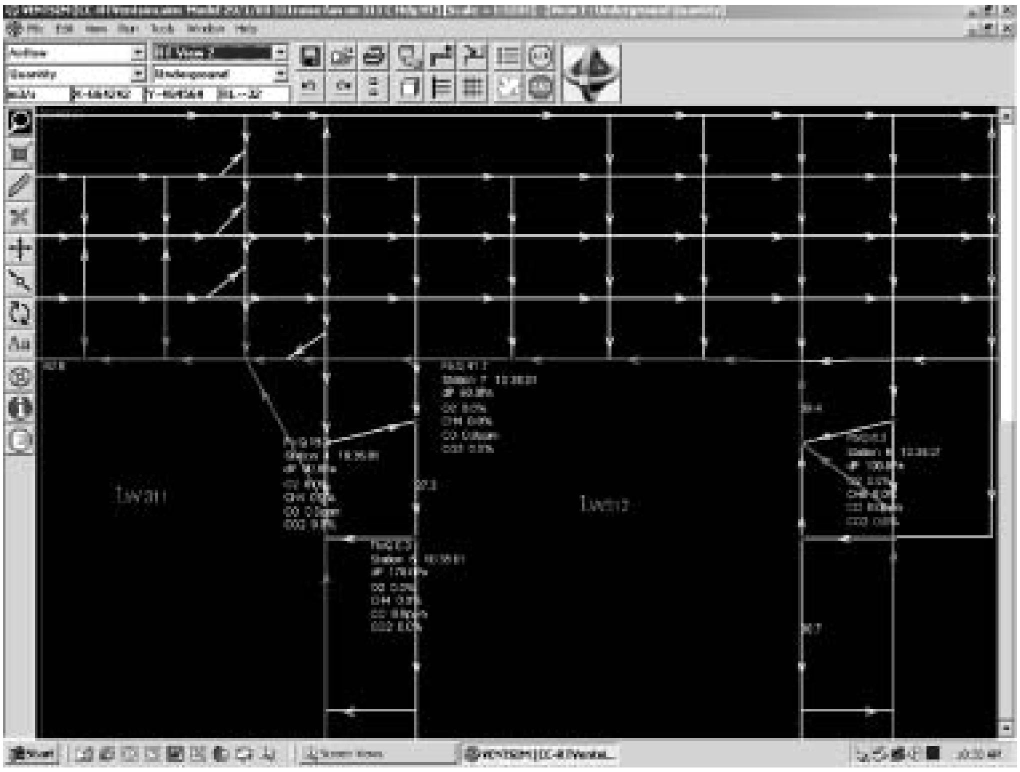


Figure 14: An example of the real time Ventsim simulation display.

A real time ventilation monitoring system can reduce or eliminate the need for numerous underground measurements necessary to verify the effects of ventilation system changes. The real time sensors installed in strategic locations will pick up airflow changes and subsequently make prediction of quantities in all other airways. However, the real time Ventsim models after detection of the changes should be modified to form an updated system model representative of the changes that has taken place and ready for future planning exercises. The project was initiated in an attempt to achieve the following benefits from improved understanding of the mine ventilation system:

- Trouble shooting that would detect any abnormal situation in the underground ventilation system directly indicating where the trouble is located (i.e. indication of airway numbers) and what type of problem is involved (eg. insufficient air quantity, air short circuiting and major leakage paths)
- Monitoring the air quantity and air quality in the return airway for determining the effectiveness of the ventilation design
- Detecting regulator failure or incorrect setting from a sudden increase of air velocity, air quantity values, and a decrease of differential pressure
- Detect stopping or seal failure from changes in airflow and the resultant potential for gas migration or spontaneous combustion
- Detecting any blockage in the airway, which will indicate the potential of roof, back or rib failure, or appropriate utilisation of equipment in the airway
- Monitoring goaf leakage due to sudden change of air velocity or air quantity and increase of gas contamination levels through incorporated real time gas monitoring system
- Providing an overall assessment of the fan performance in order to provide recommendations to alter the fan's ventilation capacity to its optimal level, and consequently saving of costs.

BHP Billiton Cannington Trial

The Cannington silver mine is located in north-west Queensland, 200km south east of Mount Isa. The deposit was discovered in 1990 and the mine was commissioned in 1997. Full production was achieved in early 1999 and since then capacity has been expanded from 1.5 mtpy to over 2.2 mtpy. Cannington is the world's largest single silver producer, representing about six percent of the world's primary silver production.

Cannington is an underground mine accessed via a 5.2m-high by 5.5m-wide decline. The main hanging-wall orebodies of the deposit are mined by transverse, longhole open sloping. During the first year of production, a vertical hoisting shaft with a finished internal diameter of 5.6m was constructed from the surface to 650m depth for ore haulage.

The ventilation system is designed around a main exhaust shaft from surface to a main return air level at the 325m level (mLv). Return air from lower operating levels is exhausted through various return air raises (RARs) or sometime ore passes connected to a collection drive on 325 mLv. The main intake airways are the decline and the hoist shaft. The system has a total combined airflow capacity of approximately 450 m^3/s.

To maintain an efficient ventilation system, it was decided to have one unimpeded open split on a level towards the bottom of the mine and install a series of regulators in the levels above to control airflow in each levels. Levels below the open split level can have booster fans incorporated within bulkheads to the RARs to assist airflow and improve conditions during hot and humid summer months (Gillies, 1999).

Initially, C-section regulators were installed and tested at each levels. However, due to the difficulty in changing the regulator setting (opening), it was decided to replace the C-section regulator with roller-door type regulators. Adjustment of the height of this type of regulator is undertaken via an automated control system. At the start of every shift regulator positions are adjusted as required via the integrated mine monitoring and control system. Airflow and/or differential pressure sensors could be incorporated as part of such an automated control system to monitor changes made. At the end of the shift prior to blasting, the regulators are set open fully to avoid the damage of the regulator caused by shock waves from blasts.

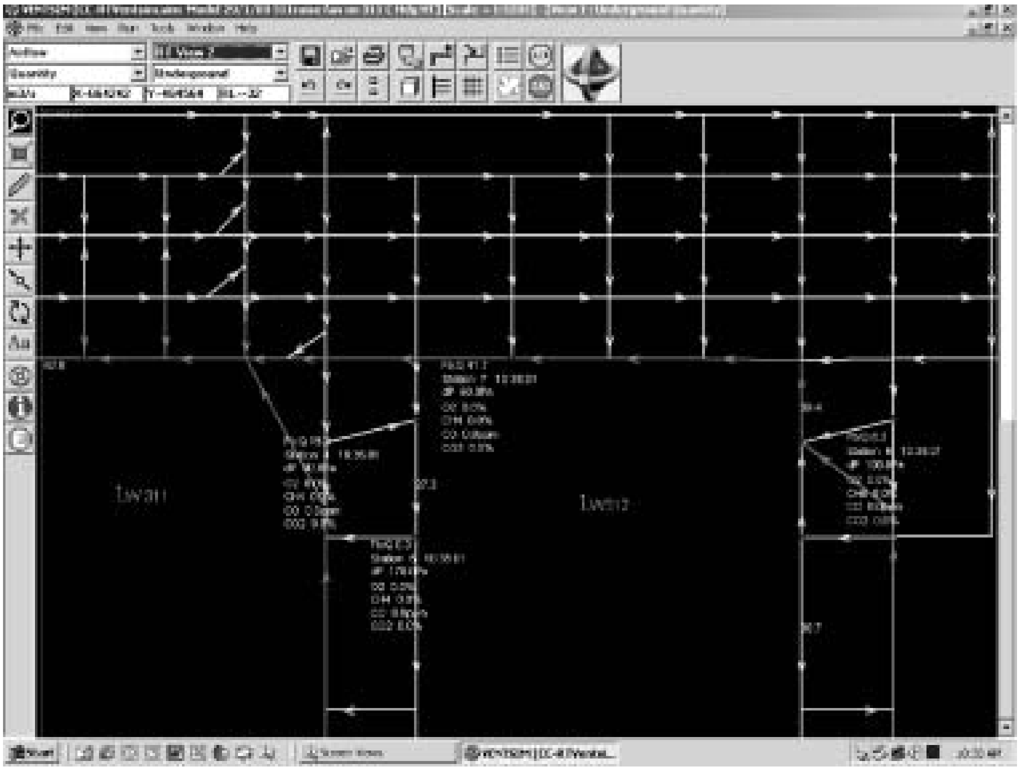


Figure 15: Snap shot of the real time Ventsim model at Cannington Sa50 RAR lower levels.

In the BHP Billiton Cannington mine, real time underground monitoring data have been transferred and displayed in their Citec mine control and monitoring system. Currently, there are nine underground remote monitoring stations planned to be included in the real time Ventilation monitoring system. These stations are mainly located at various levels accessing the Sa50 RAR and use both differential pressure sensors and ultrasonic airflow sensors to monitor airflow conditions at each station. Both Sa50 and Qb80 surface fans are also monitored and included in the system. Details of these monitoring stations and their status are as shown in the following table.

Table 3: Details of Remote Monitoring Stations Information at Cannington.

Stations	Locations	Type of Data
1	Sa 50 RAR 575 mLv Roller door Regulator	Air Quantity
2	Sa 50 RAR 550 mLv Roller door Regulator	Air Quantity
3	Sa 50 RAR 520 mLv Roller door Regulator	Air Quantity
4	Sa 50 RAR 500 mLv Roller door Regulator	Air Quantity
5	Sa 50 RAR 475 mLv Roller door Regulator	Air Quantity
6	Sa 50 RAR 450 mLv Roller door Regulator	Air Quantity
7	Sa 50 RAR 425 mLv Roller door Regulator	Air Quantity
8	Sa 50 RAR 375 mLv Roller door Regulator	Air Quantity
9	Sa 50 RAR 350 mLv Roller door Regulator	Air Quantity
10	Sa 50 Main Fans	Air Quantity
11	Qb 80 Surface Fans	Air Quantity
12	Sa 50 RAR 575 mLv Roller door Regulator	Differential Pressure
13	Sa 50 RAR 550 mLv Roller door Regulator	Differential Pressure
14	Sa 50 RAR 520 mLv Roller door Regulator	Differential Pressure
15	Sa 50 RAR 500 mLv Roller door Regulator	Differential Pressure
16	Sa 50 RAR 475 mLv Roller door Regulator	Differential Pressure
17	Sa 50 RAR 450 mLv Roller door Regulator	Differential Pressure
18	Sa 50 RAR 425 mLv Roller door Regulator	Differential Pressure
19	Sa 50 RAR 375 mLv Roller door Regulator	Differential Pressure
20	Sa 50 RAR 350 mLv Roller door Regulator	Differential Pressure

Figure 15 shows a snap shot display of the Cannington real time Ventsim model with “live” data input. Due to some specific site operational constraints, not all the regulators and sensors have been installed and calibrated to date. However, during the initial trial with only five stations online, it was found that the real time ventilation system at Cannington has the ability to detect the changes in ventilation circuit and re-simulate the network under the new conditions. Further trials will be required to evaluate the real time ventilation system behaviour more closely.

One major point of interest is the delay time or transient period between the instant of a change and when the system detects the change during the trials. The transient period in the UQEM is short and therefore is not of great significance in interpreting the network system. However, in large-scale mines like Cannington, the period can be up to 10 minutes. What this means is that reliance cannot be placed completely on “real time” airflow readings being instantaneously correct as reported for all branches within a mine ventilation simulated network. There is nothing that can be done to eliminate this characteristic as it is representative of the nature of airflow within underground mines. A change which leads to a hazardous condition may go unreported for time interval of this transient period. Of course changes in mine ventilation systems measured manually are rarely immediately picked up but this limitation of an automatically reporting real time system should be recognised.

Conclusions

Efforts to characterise or mathematically model a number of operating mine regulators have been described. Underground measurements have indicated that theoretical calculations to predict airflow quantity through practical mine regulators based on measured pressure drop are inadequate. The theoretical approaches are limited as they are based on prediction of fluid flow through a circular orifice in the middle of a plate whereas most mine regulators have a rectangular non-symmetrically positioned orifice. Also, most importantly, there is air leakage through the regulator bulkhead frame and gaps that increase actual quantity compared to that predicted.

The way to overcome this difference is to quantify the resistance of the leakage path based on regulator opening area and then to recalculate the total resistance of the regulators. The relationship between leakage path resistance and regulator opening area varies, but the resistance should increase along with an increase in opening area. Based on measured pressure difference, the airflow quantity can be predicted accurately using the basic square law. It requires field measurements to quantify the leakage path resistance of each regulator, since each regulator has its own leakage characteristic (size and number of gaps, etc.). This is a tedious work, since the regulators can be set with many opening areas. However, it was found that with limited measurement data, prediction results are still accurate within acceptable tolerance appropriate to understanding mine airflows.

The aim of the study was to gain greater understanding of a computerised monitoring system to provide immediate or real time simulated information in each branch of an underground ventilation network. The system measures airflow in selected ventilation branches and simulates flows through all other branches. Investigations were undertaken in two Queensland mining (coal and metalliferous) environments as to whether the Real Time Airflow Monitoring system can detect changes within the mine ventilation system, examine accuracy of the system and identify constraints that will limit performance of the system. As a result of trials, it was demonstrated that the system was able to detect changes occurring within the mine ventilation system and was also able to predict the changes accurately. Limitations caused by transient period delays have been examined. Updating of simulation models from use of real time data has also been discussed. It is envisaged in the future that the ventilation model would be an integral part of a real time mine wide planning, monitoring and control software platform from which the model would be updated in real time.

Acknowledgement

The support of the University of Queensland, Mr Craig Stewart and a number of operations within the Australian mining industry in funding this study are acknowledged.

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Hydration Requirements of the WMC Fertilizers Workforce at Phosphate Hill

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Abstract

Introduction: A study of the hydration requirements of the WMC Fertilizers workforce at Phosphate Hill was undertaken as part of the James Cook University (JCU) study on the workplace environment and health. The main aims of the study were to estimate the rate of fluid loss and to establish fluid intake targets for sub-groups of employees.

Methods: The study involved a.m. and p.m. measurements of weight, a measurement of fluid intake and a structured questionnaire detailing hydration behaviour and toilet activity.

Results: A total of 127 employees participated in the study. Employees working predominantly in direct sunlight have a higher median fluid loss (September, 3.7; February, 4.8 $L.kg^{-1}.h^{-1}x10^{-3}$) compared to those working in shade (September, 2.7; February 4.0 $L.kg^{-1}.h^{-1}x10^{-3}$) and air conditioning (September, 2.3; February, 3.3 $L.kg^{-1}.h^{-1}x10^{-3}$). Subjects working predominantly in direct sunlight are less likely to maintain their fluid balance than those in air conditioning and shade. The recommended body weight and task specific fluid intake targets for the workforce are:

Body weight	***Air conditioning Fluid intake target (L/shift)***	***Shade Fluid intake target (L/shift)***	***Direct sunlight Fluid intake target (L/shift)***
70 kg	4 to 5	5 to 6	6 to 7
85 kg	5 to 6	6 to 7	7 to 8
100 kg	6 to 7	7 to 8	8 to 9

Conclusions: This research study provides detailed information on the fluid loss and hydration requirements of the WMC Fertilizers workforce and demonstrates that;

- Hydration facilities and strategies for workers in air conditioning or shade appear to be adequate
- Employees working predominantly in direct sunlight require improved access to fluids
- Urine colour is an accurate indicator of hydration in the workplace
- Water is the preferred beverage for hydration in the workplace.

Introduction

A study of the hydration requirements of the WMC Fertilizers workforce at Phosphate Hill was undertaken as part of the James Cook University (JCU) study on the workplace environment and health. The study was conducted in warm conditions from Tuesday 17 to Friday 20 September 2002 and repeated in hot conditions from Tuesday 18 to Friday 21 February 2003.

The WMC Fertilizers Phosphate Hill plant is located in Australia's dry tropics where employees are exposed to relatively hot temperatures for much of the year. JCU conducted a baseline survey of the workforce health in December 2001. Elevated levels of serum albumin, aspartate transaminase, and potassium, known biochemical markers for dehydration[1,2], were observed in the workforce. This data was corroborated by an electrolyte analysis and the observed urine colours. The self-reported symptoms commonly experienced by employees at work including tired or strained eyes, dry or itchy skin, unusual fatigue and drowsiness, and headache are consistent with the known symptoms of hypohydration[3]. Therefore, the prevalence of the signs and symptoms of hypohydration among employees at the Phosphate Hill site were concerning and worthy of further investigation.

Much of the hydration research in the scientific literature has examined the short-term physical effects of hypohydration in athletic settings[4]. A balanced fluid loss and intake sustains physiological function and exercise performance[5]. Fluid loss exceeding 2% of body mass has demonstrated effects on psychological and physiological functions. Arithmetic ability, short-term memory and visuomotor tracking deteriorate significantly at –2% body mass[6]. Aerobic endurance, heat loss, sweat rate and cardiovascular function are impaired at –2% to –3% of body mass[7,8,9]. Lactate threshold occurs significantly earlier and at lower exercise intensities in subjects that are hypohydrated to –4% of body mass compared to adequately hydrated subjects[10]. These physiological effects of hypohydration are enhanced in hot compared to temperate environments[11,12].

Studies in workplace settings have identified hypohydration as a significant risk factor for heat illness due to impaired dissipation of body heat[2,13]. In hot conditions, work must be performed at slower rates to maintain a body temperature of less than 38°C[14]. High body temperature decreases time to fatigue during prolonged exercise in uncompensable hot environments[15]. While no published data are available in the scientific literature of the relationship between hydration and injury, the significant physiological and neurological effects implicate hypohydration as a potential risk factor for occupational injury.

Employees at the Phosphate Hill site are at increased risk of hypohydration and heat stress. The site is located in inland tropical Australia and employees are exposed to hot temperatures for much of the year. Mean daily maximum temperatures range from approximately 23°C in July to 38°C in December. The standard protective clothing requirements (long-sleeved shirts, long pants and helmets) for the Phosphate Hill site increase sweat rates and decrease evaporative sweat efficiency[16]. As workers in occupational settings usually perform physical activities at lower intensities, more frequently and for longer periods compared to athletes, the rates and causes of fluid loss and the hydration requirements of workers will differ accordingly.

Several long-term health effects of occupational hypohydration have been identified. These include increases in the prevalence of urinary stones[17] and dental erosion[18]. Large population based studies have demonstrated an inverse relationship between total daily fluid intake and the risk of bladder cancer[19]. Optimal hydration levels are not only vital for employees to perform physical activity and maintain optimal productivity, but more importantly, to ensure workplace safety and long-term health.

In response to the findings of the baseline health survey and the known risks, causes and effects of hypohydration in occupational settings and hot environments, an assessment of the hydration requirements of employees at the WMC Fertilizers Phosphate Hill site was conducted. The main aims of the study were to estimate the rate of fluid loss for sub-groups of employees and to establish weight- and task-specific fluid intake targets for the workforce.

Methods

The study was conducted onsite in warm conditions from 17 to 20 September 2002 and repeated in hot conditions from 18 to 21 February 2003. Participation was voluntary and all employees of WMC Fertilizers, as well as contractors of Golding, United KG, Darling Downs Tarpaulins (DDT) and Epoca at the Phosphate Hill site were invited to participate. The study involved a.m. and p.m. measurements of weight, a measurement of fluid intake and a structured questionnaire detailing hydration behaviour and toilet activity.

The Human Ethics Sub-committee of James Cook University granted approval for all parts of this study (Approval Number H1450).

Weight

Subjects were weighed fully clothed including boots but without personal protective equipment and tools. Initial weighing (a.m.) was conducted as close as practically possible to the commencement of the day shift. Repeated weighing (p.m.) was conducted prior to consumption of the main lunchtime meal. Subjects were weighed prior to obtaining urine samples.

Fluid Intake

Participants were issued with a 2 Litre insulated water container at the initial weighing and were given instructions on how to fill and empty the container and to record the number of refills. The remaining water in the container was also measured at the time of the second weighing when determining the measured fluid intake for the period of observation. Participants were advised to adhere as closely as possible to their usual hydration behaviours.

Questionnaire

Details relating to other fluid intake, food consumption and toilet activity were obtained via a structured questionnaire. Participants were asked to record the intake volume of fluids other than from the provided water container. The number of cups was recorded and the cup volume was estimated as 0.25 Litres where the cup volume was not known.

Hydration Calculations

- Total fluid intake during the period of observation was calculated as:

  measured fluid intake + other fluid intake

- Total fluid loss during the period of observation was calculated as:

  a.m. weight – p.m. weight + measured fluid intake + estimated other fluid intake

- Rate of fluid intake was calculated as:

$$\frac{\textit{(measured fluid intake + estimated other fluid intake)}}{\textit{a.m. weight x hours of observation}}$$

- Rate of fluid loss was calculated as:

$$\frac{\textit{(a.m. weight – p.m. weight + measured fluid intake + estimated other fluid intake)}}{\textit{a.m. weight x hours of observation}}$$

- Difference in rate of fluid intake and loss was calculated as:

  rate of fluid intake - rate of fluid loss

Fluid Intake Targets

Fluid intake targets for the period of a 12 hour shift were calculated as;

Median fluid loss per kilogram per hour x 12 hours x 1.5 (loss to urine factor)[20].

Subjects who had eaten their main lunchtime meal prior to the p.m. measurements and those who performed predominantly non-routine tasks were excluded from the fluid intake target calculations. No adjustment was made for toilet activity during the period of observation in any of the hydration calculations.

Results

In September 2002, 63 subjects provided a.m. and p.m. weights and fluid intake measurements and completed questionnaires. In February 2003, 64 subjects provided a.m. and p.m. weights; completed questionnaires were obtained from 61 subjects.

Employees working predominantly in direct sunlight have a higher median fluid loss (3.7 $L.kg^{-1}.h^{-1}x10^{-3}$) compared to those working in shade (2.7 $L.kg^{-1}.h^{-1}x10^{-3}$) and air conditioning (2.3 $L.kg^{-1}.h^{-1}x10^{-3}$) in September (Figure 1). Similarly, in February the median fluid loss for employees working in sunlight (4.8 L.kg^{-1}.h^{-1}x10^{-3}) is higher than for employees working in shade (4.0 L.kg^{-1}.h^{-1}x10^{-3}) or air conditioning (3.3 L.kg^{-1}.h^{-1}x10^{-3}).

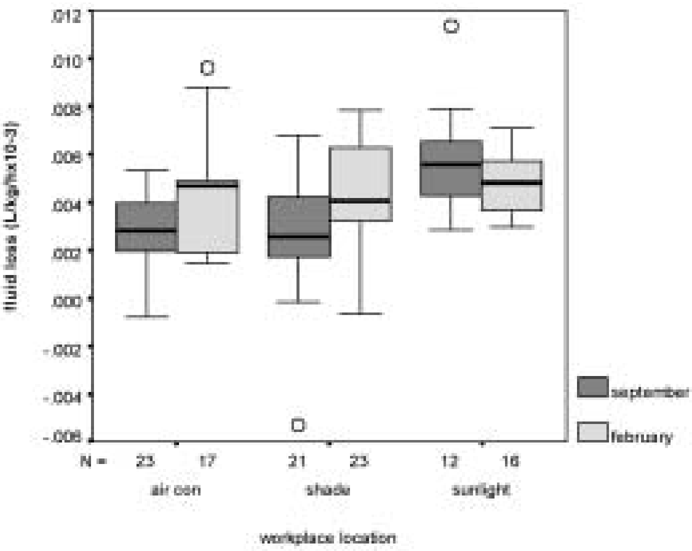

Figure 1: Fluid loss by workplace location and month.

The difference between fluid intake and loss by workplace location is displayed in Figure 2. Subjects working predominantly in direct sunlight (-1.0 L.kg^{-1}.h^{-1}x10^{-3}) are less likely to maintain their fluid balance than those working in air conditioning (-0.5 L.kg^{-1}.h^{-1}x10^{-3}) and shade (+0.7 L.kg^{-1}.h^{-1}x10^{-3}) in September. A similar trend is observed in February. Employees working predominantly in direct sunlight have a negative median fluid balance (-0.6 L.kg^{-1}.h^{-1}x10^{-3}), while those in air conditioning maintain (0.0 L.kg^{-1}.h^{-1}x10^{-3}) and those in shade improve (+0.2 L.kg^{-1}.h^{-1}x10^{-3}) their fluid balance. Fluid intake equalled or exceeded fluid loss for approximately half of the participants in both September (51%, n=32) and February (52%, n=31).

Figure 2: Difference between fluid intake and fluid loss by workplace location and month.

Fluid Intake Targets

The recommended body-weight and workplace specific fluid intake targets for the workforce are detailed in Table 1. These targets are based on the median fluid losses in Figure 1 and have been calculated as described in the Methods section.

Table 1: Recommended fluid intake targets by body weight and workplace location.

Body weight	Air conditioning Fluid intake target (L/shift)	Shade Fluid intake target (L/shift)	Direct sunlight Fluid intake target (L/shift)
70 kg	4 to 5	5 to 6	6 to 7
85 kg	5 to 6	6 to 7	7 to 8
100 kg	6 to 7	7 to 8	8 to 9

Discussion

Fluid intake equalled or exceeded fluid loss for approximately half of the participants in both September (51%, n=32) and February (52%, n=31). These results indicate that the facilities currently provided at the Phosphate Hill site in combination with the behaviour of employees working predominantly in air conditioning or shade appear to be adequate for maintaining or improving hydration in the workplace.

However, the results indicate that improved rehydration strategies for employees working predominantly in direct sunlight are required. Employees working predominantly in direct sunlight have consistently higher fluid loss compared to employees working in shade and air conditioning. Accordingly, the hydration requirements of this group are different from the rest of the workforce as their fluid balance deteriorates during their shift.

A plausible explanation for the insufficient fluid intake in subjects working predominantly in direct sunlight is access to water. Employees working in air conditioning and shade are either inside or close to site buildings and have access to taps or water coolers. Employees in direct sunlight are more likely to be further away from buildings in situations where water is not easily accessible while performing work duties. Additionally, the relatively low humidity at the Phosphate Hill site enables an efficient evaporation of sweat. Employees may be unaware of their fluid loss through sweat and the amount of fluid required to sufficiently maintain hydration. The working conditions and hydration behaviours of this sub-group of employees require further investigation to develop strategies to increase fluid intake in the workplace.

The recommended fluid intake targets for the workforce as detailed in Table 1 are based on estimates of the median fluid losses obtained in this study and are consistent with guidelines published in the scientific literature[21]. These targets cannot provide employees with an exact fluid intake per shift due to the daily variations in environmental conditions (temperature, humidity and wind speed) and individual physiological factors (aerobic fitness, endurance training, heat acclimation, gender and body composition)[22] that affect fluid loss. Rather, these figures are intended to serve as a guide only to inform employees as to their fluid intake requirements and increase fluid intake for those who may be hypohydrated. It is strongly recommended that employees use urine colour rather than the amount of fluid ingested or thirst as the most valid indicator of their hydration status, as urine colour is strongly correlated with urine specific gravity and urine osmolality[23].

A review of the scientific literature indicates that water is the preferred beverage for hydration for fluid loss rates of the magnitude observed in this study due to its availability and low sodium levels[24]. Commercially prepared electrolyte replacement drinks have a limited role and may exceed the salt requirements and may, in the long-term, even cause renal damage due to the hydrogen ion load[25], dental erosion due to low pH and diarrhoea due to high sugar levels[26]. The main advantage of carbohydrate-electrolyte beverages is their increased palatability compared to water[27]. While absorption of beverages increases with sodium content[28], rehydration can be achieved by the intake of larger volumes of fluid containing little or no sodium[29]. The electrolytes contained in regular balanced meals are sufficient to replenish any loss through sweat. Supplementary sodium chloride is usually not required for workers that are accustomed to the work duties and environmental conditions[30].

Conclusions

This research study provides detailed information on the fluid loss and hydration requirements of the WMC Fertilizers workforce at Phosphate Hill. Based on the results of this study, the following statements and recommendations with respect to the hydration requirements of the workforce can be formulated:

- The current workplace hydration facilities and strategies for people working in air conditioning or shade appear to be adequate
- People working in direct sunlight require improved access to fluids
- Urine colour is an accurate indicator of hydration in the workplace
- Water is the preferred beverage for hydration in the workplace.

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Southern Colliery - Face Bretby Handling System

Allan Gilby, Anglo Coal Southern Colliery

Allan Gilby designed the Southern Colliery Longwall Face Shearer Bretby Handling system. The Bretby Handler consists of a roller, which is installed under the Bretby and rolls along the AFC on the spill plates and handrails.

Two employees advance the roller and the Shearer Bretby is automatically lifted to allow support brackets to be installed under the Bretby. The replacement of the Bretby is the reverse of the removal.

The Bretby Handler has practically eliminated the manual handling from the removal of the Shearer Bretby. It has made the task much easier and safer. For such a simple idea, the risk of injury has been almost eliminated. The Bretby Handler has been refined to make it more suitable to the task and now we find that it has an even wider application.

The removal of the Shearer Bretby at Southern Colliery has been made far safer than it has ever been before. The Bretby Handler has practically eliminated hazardous, back breaking manual handling tasks and Allan Gilby deserves the thanks.

Image 1: Demo.

Image 2: Brackets.

Image 3: Allan Gilby.

Image 4: Close up.

No Go Zones on Vehicle Loading Cranes

BMA Blackwater Mine

BMA Blackwater Mine has implemented new design controls to greatly eliminate the risk of being crushed while operating a vehicle loading crane (VLC). The implementation of the new controls were introduced following a fatality at BMA Blackwater, where an operator of a VLC was trapped against the operator's control panel by the movement of a vehicle loading crane jib.

After comprehensive research the BMA team designed and implemented a no go zone that prevents the boom of a VLC from entering the operator's control area. The implementation of the new controls will not allow the VLC to slew over the area in which the controls are operated. The operator can still operate the VLC from both control panels, however, if they try to slew the boom over the no go zone it will slow right down forcing the operator to walk to the other controls and operate in a safe location.

The new no go zone has been developed by BMA Blackwater Mine in conjunction with Rockhampton Hydraulics and Pneumatics. The engineering controls include:

Bump Bar

A bump bar was fitted around the controls and in conjunction with proximity switches and proportional control it ensures that:

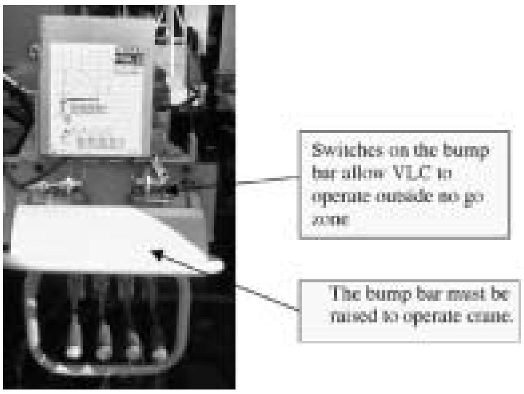
- The crane cannot be operated unless the bump bar on the operator's side is raised into the correct position
- If both bump bars are raised the crane will not operate
- If an emergency occurs and the bump bar is pushed up or down the crane will stop immediately
- Normal operation of the VLC outside the operator zone is not effected.

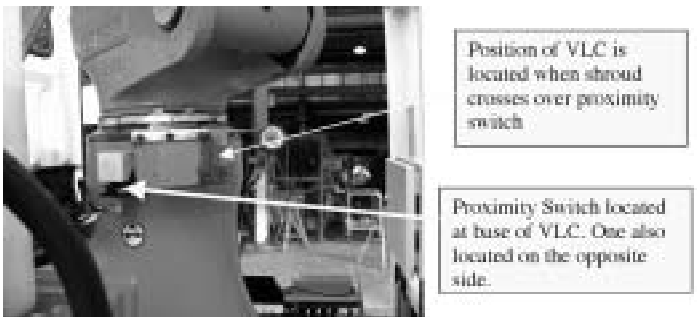
Proximity Switches

Proximity switches are attached to the boom of the VLC. The proximity switches locate the VLC's movements when slewing. This stops or slows down the slewing of the crane into the no go zone. The proximity switches also work in conjunction with the bump bar to identify from which side the operator is working the controls. The interaction between the proximity switches on the crane and bump bar prevent the booms from slewing into the no go zone when the operator is working on the same side as the boom.

The no go zone has been implemented in all VLC's at Blackwater Mine including contractor VLCs. There has been widespread interest in the new VLC modifications from various cross sections of industries, and the implications of this project seek to eliminate the possibility of a crush injury relating to VLC's.

NO GO ZONE PREVENTS BOOM FROM SLEWING INTO OPERATORS ZONE





Southern Colliery - Longwall AFC Respirable/ Combustible Dust Suppression Sprays

Wade McDonald, Anglo Coal Southern Colliery

AFC dust suppression sprays have been installed at Southern Colliery in order to reduce respirable dust on the Longwall Face.

Previously the coal on the AFC was untreated with dust suppression sprays and could travel distances of up to 240 m. The direction and speed of the AFC coupled with the ventilation velocity in the opposite direction gave rise to airbourne particles of respirable dust.

Wade McDonald of Anglo Coal, Southern Colliery developed the AFC sprays to wet the surface of the coal bed flowing along the AFC to prevent the generation of respirable dust. Careful design and installation has ensured that the sprays are integrated into the face operation. The sprays are an adjustable fire nozzle mounted on a swivel bracket installed on the AFC approximately every 40 chocks.

The sprays have been able to visibly reduce the quantity of dust generated from the AFC. This is to the benefit to all mineworkers on the Southern Colliery Longwall.

Image 1: AFC Spray.

Image 2: Turning off spray.

Image 3: Plumbing.

Image 4: Shearer Passing.

Image 5: Wade McDonald.

Minsup Isolation Lockout Device

Bob Browne, Pacific Coal's Kestrel Mine

The Problem

Kestrel introduced an isolation policy that mandated the use of locks when isolating plant and equipment on site. It was identified that approximately 500 one-inch valves throughout the air and water reticulation system on site could not be positively isolated via lockout.

The Solution

An engineering modification designed by Bob Browne allowed Kestrel to retro fit the existing valves across site. The modification is based on the principle of two holes lining up when the valve is in the closed position allowing locks to be applied and therefore ensuring positive isolation.

Process Steps

1. A preliminary rough sketch design from Bob Browne
2. Consultation with on-site local engineering company to make a prototype
3. Manufacturer of valve (Dixon Minsup) given the prototype and asked to supply Kestrel with the device that could be retro fitted to our existing valves.

Costs

This innovation has an extremely effective cost benefit of allowing modification to existing valves within air and water reticulation systems. These modifications are therefore a "one-off" expense to companies.

The cost to Kestrel for a one-inch minsup econovalve isolation lockout device is $17.00.

Transferability

The lockout device is applicable to any industry requiring positive lockout capability of one-inch minsup econovalves.

Tail Light Cleaning Sprays for 773 Water Cart

Brett Illguth, Thiess, South Walker Creek Mine

Brief Description

The Tail Light Cleaning Spray is a manually operated water jet located below the rear tail lights of a 773 water cart. The water jet is activated from the rear of the water cart and enables the vehicle's tail lights to be easily cleaned by spraying water directly onto the lights. This increases the tail lights' visibility by vehicles travelling behind the water cart.

Image 1: Rear view of water cart.

Benefits/Effects

Dirt and dust often builds up on the tail lights of 773 water carts, making the vehicle's presence, the braking indicator and indicators less visible to other vehicles.

The Tail Light Cleaning Spray helps to reduce the risk of tailgate collisions by ensuring the tail lights are continuously cleaned, increasing the visibility of the water cart.

Significance

The development of the Tail Light Cleaning Spray is a significant innovation for the mining industry due to the relatively high frequency rate of vehicle collisions across the industry.

At South Walker Creek Mine, this innovation enhances safety management by ensuring risks associated with site layout and operating conditions are significantly reduced.

Image 2: Nozzles are activated on rear spray control circuit.

Applicability/Transferability to Industry

The risk of tailgate collisions involving water carts and vehicles exists on many mines. The Tail Light Cleaning Spray is therefore an initiative that is relevant across the industry. In addition, the spray is easily implemented into water carts and through a simple modification to plant can also be transferred across similar equipment fleets.

The Tail Light Cleaning Spray can be installed in about four hours and costs approximately $500 ($300/parts, $200/labour) to implement.

Innovation & Originality

The Tail Light Cleaning Spray is an original concept and design (to the knowledge of site personnel).

Image 3: One small spray cleans immediately.

Reducing Hazards to Tyre Changing Employees

Jeff Kelly, BMA Goonyella/Riverside

Choice of Rim Design Delivers…

The mining industry worldwide has over the last few decades become increasingly dependant on a number of key mining technologies, particularly in the area of material movement by rubber tyred equipment such as trucks and loaders. As such, much of the equipment and some key components including tyres and rim components have become physically larger and often more sophisticated requiring additional skills and activities to maintain the highest levels of safety, output, reliability and cost performance.

While improvements in mine productivity and financial return can often simply be achieved through the design of proportionally larger equipment, they as an often-overlooked consequence and byproduct can also create proportionally larger hazards in the area of pit management and maintenance. One such hazard to tire servicemen and maintenance people alike is the manual handling of wheel and rim parts during wheel maintenance.

Recent reports[(1)] by the QLD department of Natural Resources and Mines have shown that manual handling injuries have not only steadily increased over the last 3 years, but now lead the injury classification by contributing to more that 50% to the overall injury makeup at QLD mines sites.

This project exemplifies the proactive and successful approach taken by both BMA and Klinge & Co to effectively address rim and tyre manual handling risks arising through the delivery of 9 new Komatsu 930E Haulage trucks at their Goonyella Riverside operation in January 2002.

The specific issue resolved by the team was the potentially high risk of suffering a manual handling injury through the repeated handling, installation and inspection process of 57 wheel nuts per wheel, other wheel components and tools.

The reduction in the associated manual handling risk was achieved trough a pre-delivery risk assessment, evaluation of suitable alternatives, selection and implementation of a risk optimal strategy. The solution chosen by the team is particularly noteworthy as it resulted in the adoption of a new style of rim designed to completely eliminate (!) the need for any manual handling of wheel nuts etc. once the rim had been installed.

As validated by the analysis to be presented at this conference, this project resulted primarily in the creation of a safer and less hazardous work environment for both tyre service men and maintenance staff through the elimination of the manual handling of wheel nuts and tool.

However this project also delivered other tangible benefits such improvement of overall safety through the selection and implementation of an inherently safer design (ie the double gutter rim), and improvement to machine productivity through reduced tire maintenance down time by 40%.

[(1)] *Safety Performance and Health Report 1 July 2001- 30 June 2002, QLD Government Natural Resources and Mines, Fig 11, various.*

Shuttle Car Cab Modifications

John Kelly & Garry O'Dwyer, Pacific Coal's Kestrel Mine

The Problem

Kestrel currently operates and maintains a fleet of 4 shuttle cars. Due to the design of the cab, the potential existed for a number of injuries to be sustained whilst operating the shuttle car, the most significant being those of a long-term ergonomic nature – back, shoulder, neck and knee injuries.

The Solution

A number of engineering solutions were implemented to eliminate or minimise problems identified with the shuttle car cab. The modifications addressed both ergonomic and other potential health and safety hazards identified.

Process Steps

1. Shuttle Car Design Review Team established (consisting of Development Supervisor, 2 x Development Operator/ Maintainers, Development Projects Supervisor, 2 x Engineers)
2. Ergonomic design review facilitated by Barbara McPhee – Ergonomic Specialist
3. Boundaries and design modifications established
4. Modifications trialled and tested
5. Final product testing prior to implementation.

Costs

The modifications are available to Kestrel at a cost of $10,500 per shuttle car.

Transferability

The design changes are applicable to all underground mining operation that utilise shuttle cars. The process steps adopted in reviewing the design of machinery is transferable to any other industry that may be considering reviewing the design of machinery at their operation.

Programmable Electronic Roof Bolter Controls

Alan Bruce, BMA Crinum Mine

The Crinum production team has continued to work towards reducing the number of strain injuries relating to roof and rib bolting and improving the efficiency of the bolting cycle within its Development operations. The team has developed and implemented the concept of installing electro-hydraulic controls on the continuous miner bolting rigs. This has provided for substantially improved access the bolting rigs for operation and maintenance.

The equipment also incorporates a semi automated drilling and bolting process which is expected with time to improve the quality of roof and rib bolting through greater consistency in the bolt installation cycle.

The 3rd aim of the system is to measure specific energy of drilling. It is planned that data obtained through this will provide site geotechnical engineers with information about the immediate roof conditions an eventually enable calculation of empirical roof strength contours, optimisation of primary and secondary support in roadways and improve our understanding for future longwall mining risk.

Monorail Chain - Removing Tool

Dan Treacy, Pacific Coal's Kestrel Mine

The Problem

At Kestrel Mine, the longwall retreats at a rate of approximately 200m over the period of a fortnight. After every 2m of retreat, the longwall monorail is lowered by removing a chain from a monorail bracket at each end of the monorail.

Previously, each time the chain was removed from the bracket, it involved an operator using a threelegged brattice stool to gain enough height to feed the chain manually through the keyhole of the bracket.

The potential existed for a number of injuries to be sustained whilst undertaking this procedure:

- Falling from the stool (especially when on uneven ground) and sustaining an injury
- Finger pinching from feeding the chain through the keyhole
- Sprain/strain injuries to the back, shoulder and neck from adopting awkward postures to manually handle the chain.

The Solution

The use of the monorail chain-removing tool eliminates the need to use a brattice stool whilst undertaking the task. This in turn eliminates both the risk of falling from the stool and the risk of sustaining a manual handling sprain/strain injury from awkward postures adopted whilst working from the stool. It also removes the operator's hand from the pinch point where the chain feeds through the keyhole therefore eliminating the pinch-point hazard.

Process Steps

1. After consultation with other longwall operator/maintainers regarding the problem associated with lowering the monorail chain, the chain-removing tool was designed by longwall Operator/Maintainer Dan Treacy

2. Once the concept was established, an on site engineering company was consulted to manufacture the tool

3. The tool was left in the panel and trialled by each of the four longwall crews. The feedback was excellent and, after some minor modifications to the initial tool, it is now the standard system for removing monorail chain from the brackets in the Longwall.

Costs

The tools are available to Kestrel at a cost of $30.00 including materials and labour.

Transferability

The monorail chain-removing tool is applicable in concept in every longwall mining operation as well as being transferable to any other industry that may remove chains from similar brackets that are hung at height.

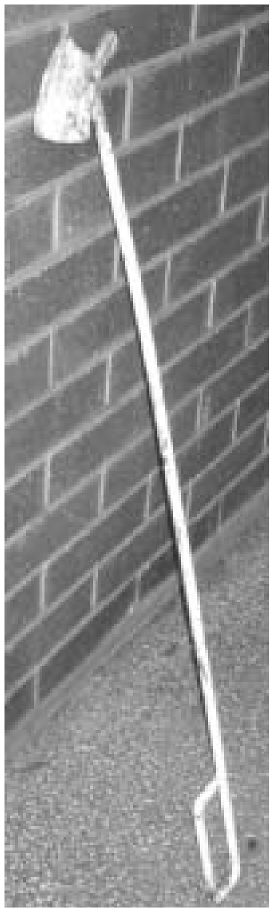


Image 1: Chain removing tool.

Image 2: Chain removing tool in use.

Washdown System for EX3500 Shovels & Excavators

Pacific Coal Pty Limited, Tarong Coal Operations

Description

Each EX3500 machine has a lube station that drops down from under the rear of the tub and retracts into a protected position during operation. This provided an ideal location for mounting the water and detergent hose couplings. From this point, permanently mounted hoses were run up internally to the upper deck. On the deck, two hose reels were mounted permanently, one for high-pressure water and the other for detergent.

Now when the Excavator or Shovel comes to be washed down, the process involves coupling the water and detergent outlets from the fixed wash stand equipment to the ground level couplings on the machine then walking up the stairway to the upper deck. Once on the upper deck, the maintainer uses the permanently mounted hoses to wash down the deck as if he were on the ground.

When the task is finished it is simply a matter of recoiling the hoses, returning down the stairs to ground and uncoupling the supply hoses from the lube station at the rear of the machine.

- *Have any modifications or improvements had to be made on first attempts to solve the problem.*

Like all good designs, this one is elegant in its simplicity and permanently eliminates a recurring hazard. No further modifications are contemplated at this time.

The Benefits

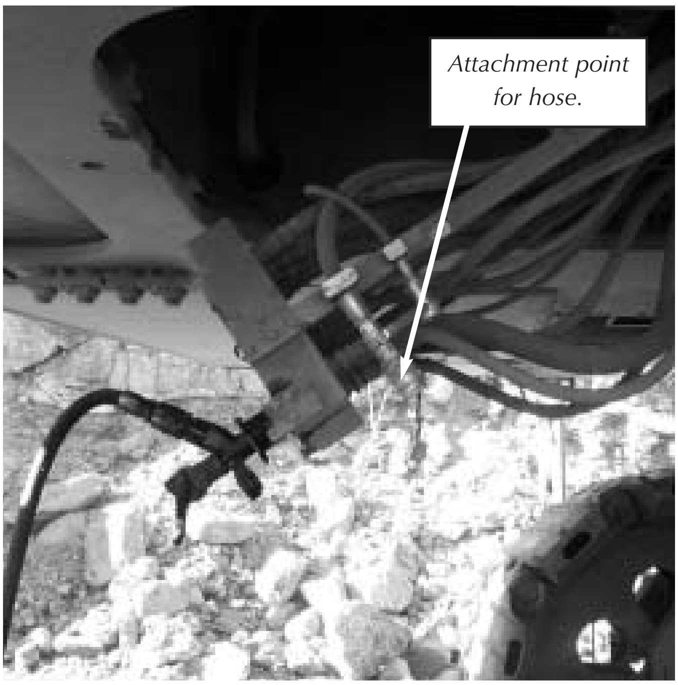
The new facility for washing down the upper deck of the EX3500 Excavator and Shovel provides the following benefits.

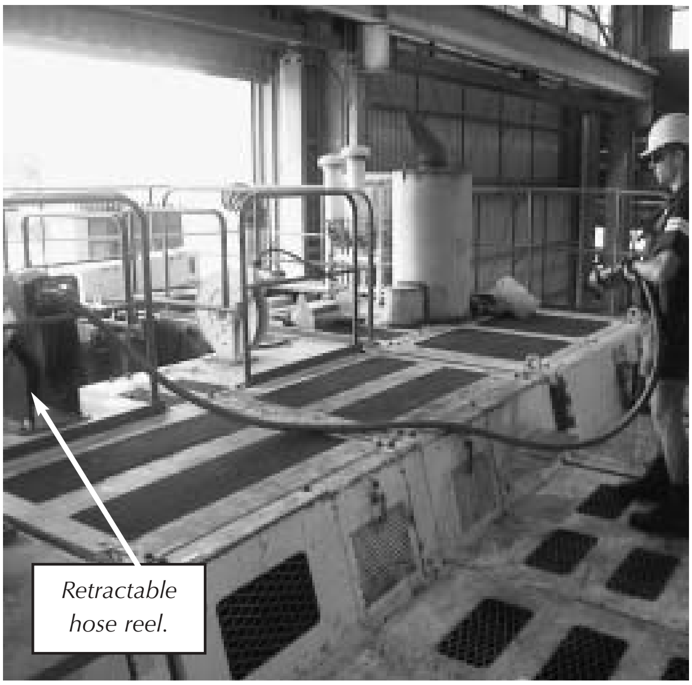
1. It removes completely the hazard of man-handling hoses from ground level to the upper deck of these machines. It provides a very elegant, first order, once-off solution to a recurring problem.

2. It improves the safety of the wash-down task with less loose hose on the deck. Previously, enough hose to reach all areas of the deck was hauled up and tied off. Now the hose reel allows just enough hose to do the job at the time to be unrolled on the deck.

3. It saves time. The new way is faster and tidier.

4. An unexpected additional benefit has been the ability to wash down the machines in the field by connecting a water truck to the new fittings.





Oxy–Acetylene Trolley

Pacific Coal Pty Limited, Tarong Coal Operations

The new trolley with the larger wheels and pneumatic tyres makes a much easier task of rolling over any differences between surfaces in and around the workshop.

The swivel jockey wheel removes the need for a man to take the weight of the trolley while moving it from place to place. The trolley is supported at a suitable angle (just past the balance point) on three wheels and does not require any vertical support by the operator. The operator is free to provide the necessary lateral force the move and maneuver the trolley as required.

The leg of the third wheel provides an ideal location to mount a fire extinguisher thus ensuring that an appropriate fire extinguisher is always present at the work site when oxy-acetylene is being used.

The impingement plate between the cylinders and the improved anchor system has increased safety and the security of the cylinders in the trolley.

- *Have any further modifications and improvements made since the first attempts to solve the problem.*

This jockey wheel has had limits placed on the amount of rotation so as to maintain the footprint of the three wheels. It was found that when the wheel rotated to the most inner position that it was too close to the centre of gravity of the trolley and there was an increased potential to topple.

Further improvements to the overall situation have been:

- The removal of the spoon drain and its replacement with a channel drain with a covering grate. This has permanently removed the issue of the dip created by the spoon drain
- The reorganisation of the space within the workshop so that the trolleys can be stored inside the main workshop.

The Benefits

The major effect of the new trolley has been to significantly reduce the manual effort required to maneuver the trolleys around the workshop.

In making the trolleys more stable and improving the cylinder anchor system, there has been a reduction in the risk of a trolley toppling over and spilling a cylinder onto the ground.

Fitting a fire extinguisher to the trolley now means that the appropriate extinguisher is always at hand whenever any oxy-acetylene work is being done.

NOTES

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