Risk assessment: An opportunity to change health and safety performance

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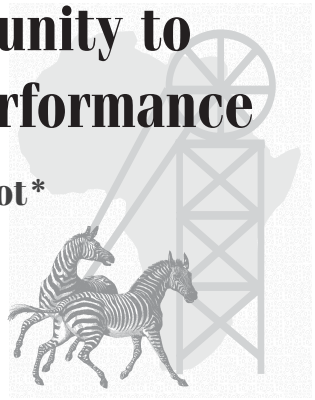

Synopsis

A common theme running through recently introduced mining health and safety legislation in many parts of the world is risk assessment. Most recently, risk assessment legislation has been introduced across the mining industry of South Africa and the view that the introduction of risk assessment based legislation provides an ideal opportunity to improve on past health and safety performance is presented.

Risk assessment techniques range from highly complex safety system techniques that are used in high technology process industries, to subjective techniques based on simple judgements that are finding use in many other industries. The objective of this paper is to shed some light on risk assessment, not by detailing the risk assessment process but by identifying the crucial elements that need to be considered if risk assessments are to be successful in changing health and safety performance.

A case study is presented illustrating the introduction of risk assessment into the Ingwe Coal Corporation, one of South Africa's largest mining houses, to indicate how the system was developed and how it is being used.

Introduction

Increasingly, mining regulatory bodies are requiring mine operators to base their health and safety assurance on the use of risk assessment. This is because it is now well recognised that risk assessment is an ideal process on which to build a pro-active safety management system that can lead to dramatic improvements in health and safety performance.

Risk assessment legislation, while providing detailed requirements, offers little by way of guidance on the way that compliance with the requirements is to be achieved. While this lack of prescription has the potential benefit of allowing a company to tailor risk assessment to its specific needs, it has the major disadvantage of providing little structure in an extremely wide, diverse and often apparently intangible field. This lack of prescription has led to the development of a vast range of procedures and processes by a wide range of researchers and consultants. Consequently, in the UK for example, where risk assessment regulations apply to almost all industries, many companies have invested a great deal of time and effort, either internally or externally, in developing and implementing risk assessment systems which, all too often, have proven to be over-complicated, expensive and bureaucratic.

There are two distinct approaches to the assessment of risk—quantitative and subjective. Quantitative risk assessment has its origins in the high technology process industries, where it is used principally to assess risks associated with 'major accident hazards'. In quantitative risk assessment, numerical probabilities of risk are calculated using various sources of engineering data, and compared against a pre-set value of acceptance. Rigorous and relatively complex formal hazard identification techniques, such as fault trees and event trees are used. In subjective risk assessment, which is more commonly used within lower technology industries, estimates of risk are based on subjective judgements of likelihood and severity. The judgements of likelihood and severity are based on some form of subjective scales and often, less formal hazard identification techniques are employed.

Whichever risk assessment technique is used, it is important to remember that the true purpose of introducing such a process is to improve health and safety. In most cases, time consuming quantitative techniques are neither practical nor necessary to achieve this end result.

Risk assessment in the international mining industry

Risk assessment has been proposed and implemented by numerous British, Australian

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and American mining and inspectorate organizations over the last few decades[1]. In the early 1970s risk assessment techniques were very analytical and were used in the high technology industries. One of the first references to the applications of such techniques in mining is given in Chalplin *et al.*[2] which states that *'several methods of evaluating (the safety of) equipment in aerospace programs have been proven of value. These methods could be applied to the mining industry with equal success'*. The authors demonstrated the use of Failure Modes and Effects Analysis, and Fault Tree Analysis, to study power systems in coal mine shuttle cars in the United States.

In the UK, the overwind at Markham Colliery in 1973, prompted research into the reliability of winding gear. The recommendations that resulted from this research considered the safety assessment methods of the Civil Aviation Authority and the Systems Reliability Service. With complex systems a fault tree approach was used[3]. Johnston *et al.*[4] recommended that both HAZOP and fault tree analysis had potential applications in the UK mining industry and discussed their use with respect to air conditioning in mines and winding systems respectively.

In the US, a report by the USBM[5] considered the formal techniques of hazard identification that existed and their applicability to mining. They proposed that 'Failure Mode and Effects Analysis' and qualitative human reliability assessments could be used immediately in the mining industry and that 'event tree analysis', 'fault tree analysis' and 'quantitative human reliability assessment' be recommended for future adaptation into the mining industry. However, these investigations do not appear to have resulted in widespread application of the technology at operating mines[6].

In the Australian coal industry, engineers began looking at the application of such techniques in the mid-1980s, with the result that funding was provided to trial various techniques in underground mines[6]. These trials were successful, and in 1991 the New South Wales Inspectorate mandated the use of a structured hazard analysis as part of the approval process for new operations or equipment[7]. Whilst initially such techniques were greeted with a negative response from the mine operators, operator initiated studies now outweigh Inspectorate initiated studies by a factor of at least 10 to 1[1].

As a result of the trials it was suggested that less sophisticated, subjective risk assessment techniques could play a vital role in reducing many forms of mining loss. Similar conclusions were reached when studies were undertaken regarding the introduction of risk assessment in UK legislation in 1992. Staley[8] considered that the application of complex techniques to the UK coal industry was unlikely to be fruitful. A more promising approach was considered to be the introduction of a more simplistic risk assessment system.

The Australian trials also concluded that Quantitative Risk Assessment (QRA), as used in the petrochemical and nuclear industries, had no immediate application in the mining industry. Principally, this was due to industry cultural differences and the limited available data. Comprehensive data on equipment failure and enhanced accident/incident reporting schemes were required for QRA to be of value.

Risk assessment in the South African mining industry

In South Africa the Mine Health and Safety Act (Act 29 of 1996) introduced a requirement for employers to assess the risks to the health and safety of their employees and persons affected by their undertakings. It can be said that initially the industry was daunted by this potential task for a number of reasons. At this time risk assessment was widely considered to be another duty in an overloaded work schedule. Risk assessment was new, not widely understood, and perceived as duplicating work that was currently being done, albeit with a different title. As a result the potential benefits were not fully appreciated. There was some justification for these views. If not carefully planned and managed, risk assessment can be just another paper exercise, with no true benefits to health and safety performance. However, risk assessment was mandatory, unlike many of the safety activities that had been undertaken previously.

The industry needed to improve its health and safety performance. The statutory need to introduce risk assessment provided an ideal opportunity to change health and safety performance by 'drawing a line' under the old and often ineffective systems, reviewing the current position and starting again.

The essential elements of risk assessment

Although there is an almost bewildering range of approaches and risk assessment techniques, in essence, they all contain the same fundamental steps. These are:

- Identify hazards–something with the potential to cause harm
- Assess the likelihood, or probability, of harm arising from the hazard
- Assess the severity of harm resulting from realization of the hazard
- Combine assessments of likelihood and severity to produce an assessment of risk
- Use the assessment of risk as an aid to decision making.

Based on the fundamental steps above, the view that risk assessment is 'nothing new' but rather a new 'buzz word' for similar systems that have been used in the past has considerable merit. Risk assessment is simply a method for identifying hazards and helping to decide what, if anything, we are going to do to eliminate or reduce the risks that arise from them. This is 'nothing new', rather it is something that people do every day of their lives. Consider the following simple example of crossing the road.

To cross the road safely, we stop and look at the traffic. If a car or lorry is close or travelling fast, there is a high risk of being run over and we do not cross. If there is no traffic, or it is moving slowly and a good distance away, then there is a low risk of being run over and so we cross the road.

This simple situation is an example of risk assessment. The hazard, being run over, was identified and a subconscious assessment of risk made, by considering: The *likelihood* of things going wrong and the *consequences* if they do.

On this basis, risk assessment is 'nothing new'. It does however, provide an opportunity to critically review health

and safety performance and to introduce more effective and efficient health and safety assurance systems. To fully capitalize on this opportunity, it is necessary to identify those aspects of risk assessment that will make a positive contribution to the industry's health and safety performance.

Past experience in other countries and industries has shown that the key to ensuring positive health and safety improvements through the introduction of risk assessment lies in:

- identification of hazards
- reviewing the effectiveness of existing risk control measures
- the introduction of additional controls, or control improvements.

When undertaking a risk assessment, choosing the level of detail used for hazard identification is very important. An insufficient level of detail may overlook some hazards whilst an excessive level of detail can detract from the effectiveness of the overall process, by concentrating too much on trivial matters. Therefore a compromise between the two must be sought. The South African Tripartite Guidelines[9] and UK Regulations use the terms 'suitable and sufficient' for the level of hazard identification, stating that 'the level of detail in a risk assessment should be broadly proportionate to the risk'.

Within the mining industry there is a wealth of control measures that have been introduced over the years as the industry has developed. It is fair to say that if all these measures were effective, then there would be far fewer accidents than there are at present. In a risk assessment, when identifying what controls are currently in place, it is vital to review the effectiveness of each control, to identify any shortcomings, and to assess how effective it is in practice.

If shortcomings are identified, it is necessary to determine why they occur. For example, if personal protective equipment (PPE) is identified as a current control measure but is infrequently worn, then its reliability as a control must be questioned. It is not sufficient to try to solve the problem by recommending *'enforce the use of PPE'*. It is necessary to determine why the PPE is not worn and often this root cause then provides the route to an effective solution. This is analogous to many accident investigations. How many accident forms are there, even today, that state the obvious cause as 'failure to follow standards'? Such a statement does not provide sufficient information to enable positive and effective action to be taken.

Table 1
Conflicting instructions

Safety Department Material	Action Required by Driver	Training Department Material
One Long Blast	Stop	One Long Blast
Two Long Blasts	Move Ahead	One Short Blast
Three Long Blasts	Move Back	Two Short Blasts
2 x 2 Short Blows	Slowly Forward	
3 x 3 Short Blows	Slowly Backward	
One Long Blast	Hopper Full	
	Warning of Danger	Multiple Short Blasts

Standard procedures are among the most common hazard control measures used in mines. If a control shortcoming is identified as, *'procedures not being followed'*, the effective solution is often not as straightforward as enforcement, or discipline, or re-training. Table I shows an example of conflicts found at a mine between the written procedures for locomotive drivers held by the safety department and the procedures being taught by the training department.

Where a 'failure to follow standards' is identified, if real improvements to health and safety are to be achieved, it is necessary to determine why they are not being followed. There is a need to ask questions such as:

- Are the procedures practical?
- Does everyone know the rules?
- Has everyone been trained?
- Is the training effective?
- Is the supervision effective?
- Do people 'turn a blind eye' to rule breaking?

Initially, assessing control reliability can seem like quite a daunting task. However, in many cases it is not as difficult as it first appears. Although situations may be encountered where expert advice is required to assess or improve control reliability, on most occasions the experience of those who supervise or do the job will provide the answers.

If the potential to improve health and safety standards via the introduction of risk assessment is to be realised, it is absolutely essential to *assess what really happens* rather than what should happen.

The need for risk management

Although risk assessment plays an important role in identifying hazards and providing strategic advice on the relative risks to health and safety, on its own it does not make an operation any safer or more efficient. That objective is achieved through risk management, by ensuring the selection, implementation and maintenance of effective initiatives to improve health and safety performance. Risk assessment without such a deliberately designed and complementary risk management component is a waste of time, money and effort.

For a risk management system to work efficiently, there are two important requirements which have to be fulfilled. The first of these is visible commitment of all senior managers, through an active involvement in the process. The second is the widespread involvement and participation of the workforce. In this way, the entire workforce will start to recognise the benefit of their input and start to take a greater interest in 'ownership' of their own safety. Used in this way, risk management can be a strong motivational tool.

Planning for risk assessment

Risk assessment is not a one-off exercise, but rather a continuous process that affects mines and miners for the rest of their working lives. It is not something that is going to 'go away' or be replaced in a few years' time by the next safety 'buzz word'. The introduction of such a process and making

it work is going to take time. This fact needs to be appreciated, as risk assessments cannot be completed overnight and implementing them, through risk management, takes longer.

Due to the vast and varied nature of current mining operations, in order to undertake routine assessments for all such operations, it is important to plan the risk assessment and management programme. The assessments that need to be undertaken first are those concerning significant hazards and *operations with the highest accident potential*. The identification of these is referred to in the South African Tripartite Guidelines on Risk Assessment[9] as a 'baseline' risk assessment. In other industries it is commonly called a Preliminary Hazard Analysis (PHA). This analysis provides the basis for a more timely and complete study on the hazards and operations which are associated with higher risks.

Risk assessment and risk management in Ingwe Coal Corporation

Ingwe Coal Corporation was formed in 1995 out of the merger of the coal mines of Rand Coal and Trans-Natal. The company is the world's largest steam coal exporter and has a large internal market in South Africa supplying coal to the power generating authority Eskom, as well as sugar and paper mills. Ingwe operate ten mines in South Africa, nine of them in the Mpumalanga province and, through Coal Mines Australia Limited, operate four mines in Australia.

Ingwe's objective in introducing risk assessment and management was not only to meet the pending statutory requirements, but to become an internationally recognised benchmark company in terms of their health and safety performance.

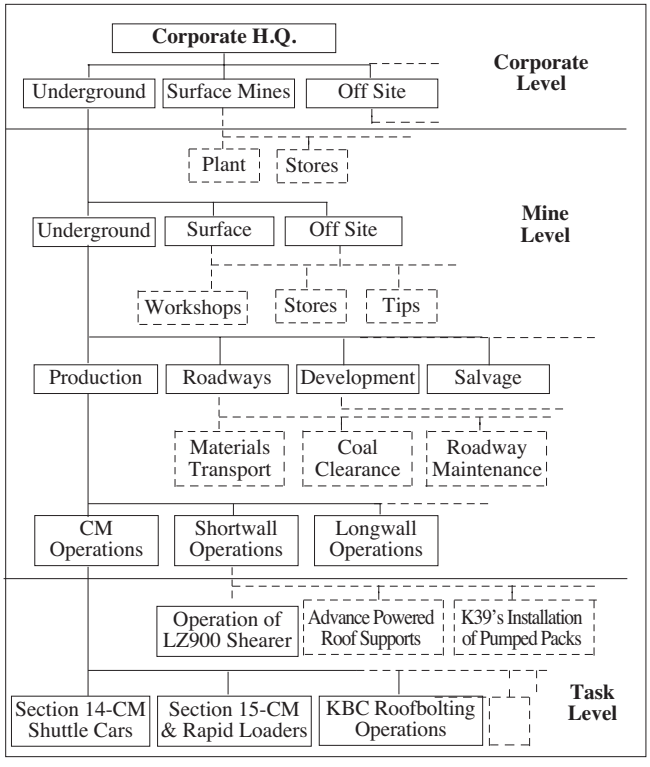

Figure 1—Example risk hierarchy at Ingwe Mines

To avoid the pitfalls and problems experienced by other organizations in the past, a number of experts in the field of risk assessment, both national and international, were requested to undertake presentations to a group of representatives from all Ingwe stakeholders, outlining their proposed approach to the risk assessment process. Following this, International Mining Consultants Ltd (IMC) were chosen as the most appropriate organization to assist with the development of an Ingwe Risk Assessment and Risk Management (RA/RM) Process.

In consultation with Ingwe staff, the IMC brief was to develop a practical health and safety risk assessment process, define roles, responsibilities and reporting lines and the process for translating risk assessment findings into an effective health and safety risk management system. The objective was to empower Ingwe staff to implement the RA/RM process, rather than having to depend on external consultants to conduct or facilitate the risk assessment process. Consequently a series of comprehensive training packages were developed.

The first training packages were used in September 1996 to train mine training managers and the newly-appointed 'Risk Managers' whose role would be to co-ordinate the health and safety risk assessment and management process. After attending these intensive training courses, the training managers identified the training needs for the rest of the company.

In January 1997, training was given to all the Senior Operations Managers, Mine General Managers and their respective mine management teams, including the recently appointed full-time health and safety representatives. Following this training each General Manager and his team developed the specific strategy that would be used at their mine, to facilitate the implementation and operation of the Ingwe RA/RM process.

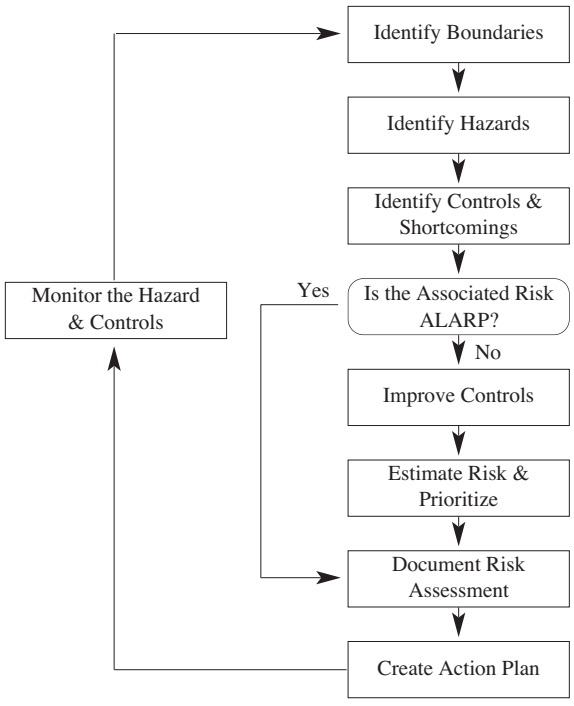

Figure 2—The Ingwe-IMC rationalized RA/RM process

The Ingwe RA/RM process

Within the Ingwe RA/RM process, risk assessments are conducted at three levels within a hierarchical structure. An example of such a hierarchical system is shown in Figure 1.

Corporate level assessments are used to address the major hazards to health and safety that are generic to Ingwe mines. This approach enables minimum corporate standards to be set and helps to ensure that consistent standards of risk control are applied and maintained across Ingwe mines. In effect, it provides a rational mechanism for the selection and issue of corporate directives.

Mine level assessments are used to address those hazards and risks which are common in a particular mine, or across a wide range of similar operations within a mine. Corporate assessments and control standards are also reviewed at mine level. Where risks are potentially higher, for example due to local mining conditions, additional mine control requirements can be added to the corporate requirements. Hence, consistent mine control standards are set.

Task level assessments address hazards that are specific to operations, tasks and areas of the mine. Again, these take cognisance of mine level assessments and standards and identify any necessary additional controls or improvements.

The Ingwe RA/RM process is used to conduct risk assessments within all of the levels described above. An outline of the Ingwe RA/RM process is shown in Figure 2.

There are two notable differences between the rationalized process as shown and approaches being adopted by others within the industry. The first of these is the consideration and documentation of *control shortcomings,* which are factors that reduce the effectiveness of control measures and hence, increase the risk of a hazard occurring. In the vast majority of cases, experience, in particular the experience of those who do the job, provides sufficient insight to enable sound judgements on control effectiveness to be made. This is a clear demonstration of one of the many advantages to be gained from ensuring participation and involvement from the workforce at all levels within the mine.

The second notable difference lies in the ranking or estimation of risk. This is undertaken only after consideration of existing controls and their shortcomings, or effectiveness, and after asking the question, 'Is the risk from the current hazard controlled to a level that is "As Low As Reasonably Practicable" (ALARP)?'

The only value in estimating risk is that it acts as a guide when determining the relative priorities to be assigned to the implementation of remedial actions. If current risks are adequately controlled, and hence considered to be ALARP, then risk estimations are unnecessary. When required, subjective estimates of risk are made using a simple matrix-based approach. Two matrices are used, one for health risks and the other for safety risks. The content of these matrices is shown in Table II.

As stated earlier, risk assessment is of little or no value in improving health and safety without a management system to support it. Having undertaken a risk assessment, it is necessary to identify the remedial actions required to reduce risk, and hence improve health and safety, allocate priorities, and ensure effective implementation–in other words, to effectively manage health and safety risk. Within the Ingwe process, action plans are used to support this management process.

Table II

Ingwe H&S risk estimation matrices

Accident Severity					**Health Severity**
Injury	1	2	4	7	Irritant
Disabling Injury	3	5	8	11	Temporary disability
Permanent disability	6	9	12	14	Permanent disability
Fatalities	10	13	15	16	Death
Likelihood	Once a Year	Once a Quarter	Once a Month	Once a Day	Likelihood

Action plans identify the actions to be taken, the person(s) responsible for undertaking them, target completion dates and review dates. Review dates are used to trigger checks on implementation progress and follow up assessments of risk and control effectiveness. Action plans also support the mechanisms used to inform those affected by the risks and indicate how they will be informed (i.e. through training, 'tool box talks', etc.).

Conclusions

Risk assessment techniques will play an ever increasing role in ensuring the health and safety standard of mining operations. The introduction of risk assessment in the South African mining industry presents a real opportunity to change and improve health and safety performance. To do this successfully, it is vital that there is real commitment to change, to ensure that the process does not turn into yet another 'back protecting' paper exercise. Risk assessment requires a well planned health and safety management system to ensure that improvements are implemented and to encourage widespread stakeholder participation. The important elements of risk assessment are the identification of significant hazards, their associated controls and, in particular, control shortcomings and/or effectiveness.

Through the collaboration with IMC, Ingwe have avoided many of the pitfalls and problems experienced by other organizations. This collaboration, combined with the high level of commitment demonstrated by Ingwe personnel, has resulted in the introduction of what is widely acknowledged as the most efficient and practical health and safety risk management process within the South African mining industry to date.

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The XXI International Mineral Processing Congress

The Mineral Processing Congress will be hosted by the University of Rome 'La Sapienza' from 23 to 28 July 2000 at the Hilton Rome Cavalieri Congress Center in Rome, Italy. In the tradition of the IMPC series, which dates back to 1952, the Congress will once again provide the definitive forum for the presentation of new knowledge in the science and technology of mineral processing, as well as an opportunity to discuss and evaluate the application of research results in industry. Due to the increasing importance of the application of mineral processing techniques in waste treatment, recycling and soil remediation, special attention will be paid to these topics at the XXI IMPC. A special session will be devoted to the processing of raw materials for glass and ceramics.

Authors wishing to present papers are requested to submit an extended abstract not exceeding one page or 300 words, *no later than December 31st 1998*. Authors will be advised of acceptance or otherwise by March 15th 1999. The completed papers will be due on September 15th 1999 together with a Congress deposit fee of U.S.$ 150. Authors will then be advised of the Scientific Committee's comments and should return the revised papers by January 31st 2000. The revised papers are to be submitted both in hard copy and in electronic format. Microsoft Word is preferred, but WordPerfect or ASCII text are also acceptable.

The official language of the Congress is English. All papers should be submitted in English. Simultaneous translations may be provided in French, German or other languages for invited lectures.

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In conjunction with the Congress a major mineral processing exhibition will be held.

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