Reducing accidents in the mining industry—an integrated approach

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Transaction Paper

Synopsis

The platinum mining industry has experienced a significant increase in fatal accidents. Mine accidents are in principle preventable, and there is enormous pressure on employers to reverse this trend. This paper reviews safety management systems (SMS) as well as behaviour-based safety (BBS). Based on the review, SWOT analyses are performed on the SMS and BBS processes and a model of an integrated safety management system (ISMS) is introduced. A number of fatal accidents is analysed to identify factors that contributed to accidents in the mining industry. Thereafter the potential weaknesses of an SMS of a platinum mine are exposed and the potential benefits of implementing the ISMS for this case study are demonstrated.

Introduction

Fatal accidents in the North-West mining region of South Africa have increased significantly since 1999 (see Figure 1[1]). During 2002 the North-West region experienced the worst ever year in terms of total fatalities, which is one indicator of safety performance*. The fatality rate (deaths per 1 000 employees) increased from 0.61 in 2001 to 0.86 in 2002[1]. In 2003 it was again 0.63. However, the platinum industry, which is mostly based in the North-West Province, has been expanding in the past few years and is subsequently facing the risks associated with increased mining depths as well as longer tramming distances. Figure 2 shows the number of fatal injuries associated with platinum mines in South Africa[1]. While expansion is critical for employment and economic growth in South Africa, it cannot be done at the expense of health and safety.

Under the Mine Health and Safety Act (MHSA)[2], the primary responsibility for ensuring a healthy and safe environment rests on the employer. Employers depend a great deal on safety management systems (SMSs) in their endeavours to eliminate unsafe conditions. This, however, does not effectively address at-risk behaviour that, according to Schutte[3], contributes to 88% of workplace accidents. To combat this threat, many organizations are implementing what is referred to as behaviour-based safety (BBS) programmes. The purpose of this research project was to develop an integrated safety management system (ISMS), which incorporates the aspects of BBS with conventional safety management practices.

*It must be noted that there are other indicators of safety performance, e.g. days lost, and normalizing a group of indicators would provide for a more meaningful comparison of safety performance

Literature review

Safety management systems

The International Labour Organisation (ILO) has developed voluntary guidelines[4] that ought to contribute to the safeguarding of workers from hazards along with the elimination of work-related injuries, ill health, diseases, incidents and deaths. However, it is necessary to establish occupational safety and health (OSH) policies to provide direction for decision-making through a formalized safety management system (SMS).

Hermanus[5] emphasizes the importance of involving workers and their representatives directly in the OSH decision-making process. The necessary OSH competence requirements must be defined and arrangements established and maintained to ensure that all persons are competent to carry out the safety and health aspects of their duties and responsibilities. Measurable specific OSH objectives consistent with the OSH policy should be established for the organization. These objectives have to be consistent with relevant and applicable national laws and regulations, as well as the technical and business obligations of the

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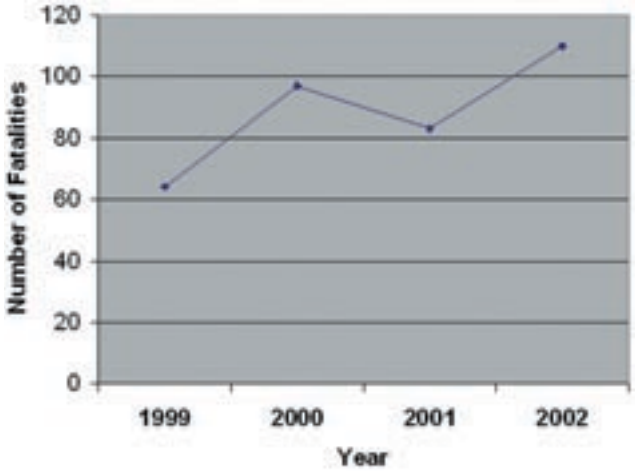

Figure 1—Number of fatalities in the North-West region of South Africa

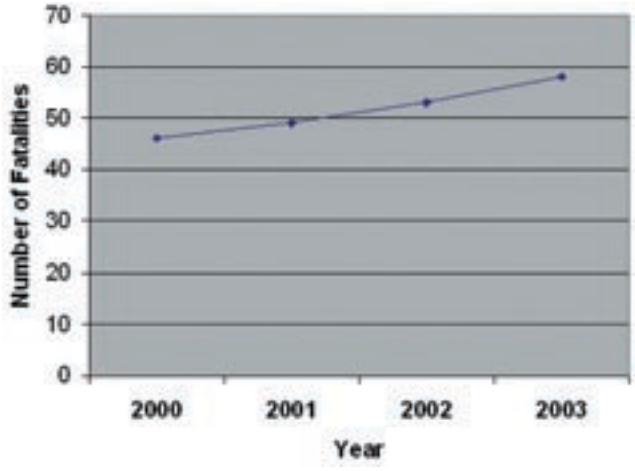

Figure 2—Number of fatalities in South African platinum mines

organization with regards to OSH. Hazards and risks to the safety and health of workers should be identified and assessed on an ongoing basis. Preventative and protective measures should be implemented in the following order of priority[6]:

Eliminate the hazard/risk
Control the hazard/risk at source, through the use of engineering controls or organizational measures
Minimize the risk/hazard by the design of safe work systems, which include administrative control measures
Where residual hazards/risks cannot be controlled by collective measures, the employer should provide for appropriate personal protective equipment and implement measures to ensure its use and maintenance.

The impact on OSH of internal changes, such as those in staffing or due to new processes or working procedures, as well as external changes, for example as a result of amendment of national laws or development in technology, should be evaluated and appropriate preventative steps taken to mitigate risks prior to the introduction of changes. Emergency prevention, preparedness and response arrangements should be established and maintained. Procurement procedures should be established and maintained to ensure that compliance with safety and health requirements for the organization is identified, evaluated and incorporated into purchasing and leasing specifications. Arrangements should also be established and maintained for ensuring that the safety and health requirements of the organization are applied to contractors and their workers.

Procedures to monitor, measure, and record OSH performance on a regular basis should be developed, established and periodically reviewed. The investigation of the origin and underlying causes of work-related injuries, ill health, diseases and incidents should identify any failures in the OSH management system and should be documented. Corrective actions resulting from such investigations have to be implemented to avoid recurrence. Arrangements to conduct periodic audits should be established in order to determine whether the OSH management system and its elements are in place, adequate and effective in protecting the safety and health of workers and preventing incidents.

Regular management reviews should evaluate the overall strategy of the OSH management system to determine whether it meets planned performance objectives. Arrangements should be established and maintained for preventative and corrective actions resulting from OSH management system performance monitoring and measurement, OSH management system audits and management reviews. These arrangements should include identifying and analysing the root causes of any non-conformity, as well as the initiating, planning and implementing of corrective and preventative action in an appropriate and timely manner. Arrangements should be established and maintained for the continual improvement of the relevant elements of the OSH management system and the system as a whole. The safety and health processes and performance of the organization should be compared with other organizations in the same mining sector to improve health and safety performance.

Behaviour-based safety

The phrase behaviour-based safety (BBS) refers to the use of applied behaviour analysis methods to achieve improvement in safety performance[7]. To actually achieve long-term continuous improvement, these methods need to be coupled with significant employee involvement. Once it has been established, the behaviour-based continuous improvement safety process represents a closed loop, as indicated in Figure 3.

The reason to focus on behaviour is that when an incident occurs, behaviour is the crucial final pathway that brings other factors together in an adverse outcome. Therefore, ongoing, upstream measurements of critical at-risk behaviours provide the most significant indicator of workplace safety[7]. The at-risk behaviours in question are the work practices of the organization, which are necessarily interwoven with management systems, including safety systems. As the frequency of at-risk behaviour escalates, the probability that injuries will occur increases. Krause[7] further maintains that the behaviour-based approach improves safety attitude and culture by identifying and then managing changes in the behaviours that are critical to safety.

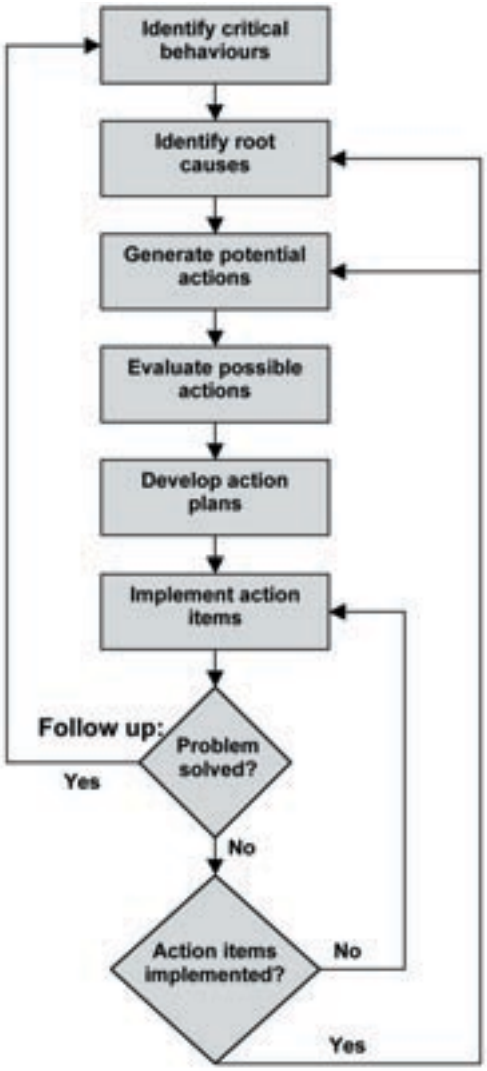

Figure 3—The behaviour-based safety process

Attitudes are formed by perceptions, the process by which people select, organize, interpret, receive and respond to information from the world around them. Formally defined[8], an attitude is a predisposition to respond in a positive or negative way to someone or something in one's environment. Attitudes focus on specific people or objects. An attitude results in intended behaviour; this intention may or may not be carried out in a given circumstance. Figure 4 illustrates attitude as accompanied by perception and behaviour. Most people naturally register the sequence of attitude change followed by a change in behaviour, but Lund and Aaro[9] put forward a more comprehensive model indicating that behaviour change also causes a change in attitude (see Figure 5).

Because behavioural science provides a method for measuring and managing the mass of behaviours, it cuts through the indirectness of individual actions. Krause[7] therefore argues that there is no need for a detour that addresses attitudes first to get to behaviours later. Behavioural norms are the very heart of culture, so a change in behavioural norms is central to any successful culture change effort. Krause further claims the basic tool of applied behaviour analysis is known as ABC (Antecedent, Behaviour and Consequences) analysis. In terms of this analysis, an antecedent is an event that triggers an observable behaviour. A consequence is any event that follows from that behaviour. Although the antecedent is important, applied behaviour analysis demonstrates that consequences are more powerful determinants of behaviour than antecedents. On its own, the antecedent does not directly determine the behaviour. Instead antecedents elicit certain behaviours because they signal or predict consequences. It is the goal of ABC analysis to discover which antecedents and consequences are influencing a particular behaviour. Once these factors are known, they can be changed; and when the antecedents and consequences change, behaviour changes. In summary, antecedents and consequences influence behaviour in different ways. Consequences have a powerful and direct influence on behaviour, whilst antecedents have an indirect influence on behaviour, primarily serving to predict consequences.

In addition to discovering that consequences are stronger than antecedents, some consequences are stronger than others. There are three features that determine which consequences are stronger than others[7]:

Timing—a consequence that follows soon after an action influences behaviour more effectively than a consequence that occurs later
Certainty—a consequence that is certain influences behaviour more powerfully than an unpredictable or uncertain consequence
Significance—a positive consequence has a stronger influence than a negative consequence.

These three rules mean that the consequences, which have the most power to influence behaviour, are those which are simultaneously soon, certain and positive. By contrast, the weakest consequences are the ones that are late, uncertain and negative. It is not the point of BBS management to change human nature, but rather to change the safety culture in order to use the nature of behaviour in favour of safety instead of against it. This amounts to devising consequences for safety that are soon, certain and positive. The initial soon-certain-positive consequences in favour of safe behaviour build new attitudes towards safety. These new attitudes, in turn, become the source of both broader and more finely tuned attention to safety, bringing new soon-certain-positive consequences to bear on the safety performance of the organization. In this way, a continuous improvement process is established, becoming a safety mechanism.

Analogy between traditional SMS and the BBS processes

Based on the literature review of SMS and BBS processes, SWOT analyses have been performed[9] on both processes to serve as basis from which the similarities and differences between the SMS and BBS processes are highlighted. Tables I and II summarize the SWOT analyses[10].

Conclusions from the SWOT analysis

The literature review of the major trends in the field of safety management reveals that the traditional systems approach to occupational health and safety stems from the idea that within companies, junior managers, supervisors and workers

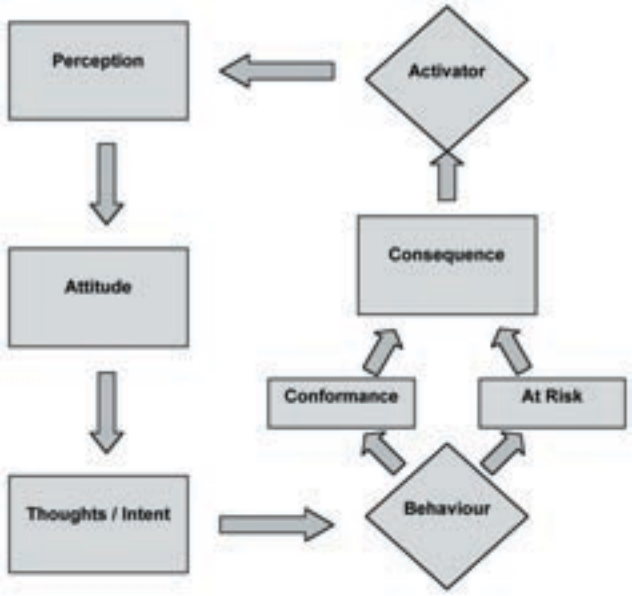

Figure 4—Behaviour impact

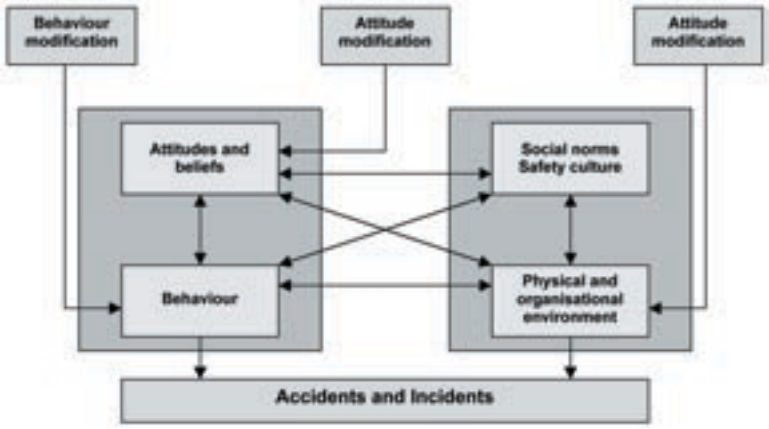

Figure 5—Model for accident prevention

on the floor take their cue from the top. Reduction in the incidence of occupational injury and disease is sought by adopting a systematic approach to prevention, which involves the identification of hazards, the planning and monitoring of preventative measures, and integrating health and safety related criteria into routine work and decisions at all levels of the organization. Although employee involvement provides the means through which workers develop and express their own commitment to safety and health, safety management systems are often too systems focused, with not enough regard for human factors. This can be corrected by integrating the positive aspects of behavioural-based safety processes into these traditional safety management systems.

Conceptual model of an integrated safety management system

It is proposed to integrate the positive aspects of SMS and BBS to form an integrated safety management system (ISMS), as indicated in Figure 6[10]. The traditional safety management system is envisaged to form the backbone of the ISMS. The safety management system standards would provide the means for an organization to manage and control risks. The positive aspects associated with BBS will be exploited to develop employee participation as an integral component of the entire system. Lewis[11] claims that participative management is one way that an organization can establish a supportive environment. Schutte[3] found that a substantial part of the workforce perceives that the way they are treated impacts negatively on their job attitude. A commitment to good corporate business and social practices is therefore fundamental to providing the basis for the proposed ISMS. The workforce is also less tolerant of traditional hierarchical structures. Applying hard-nosed tactics to subordinates becomes demoralizing. Front-line supervisors consequently have a great deal of influence over safety efforts and safety culture. Leaders must have the ability to align, motivate and encourage employees in a way that will create and enhance a harmonious and motivating work environment, conducive to a committed and empowered work force.

Table I

SWOT analysis of SMS processes

Strengths	Opportunities
• Directs a company towards compliance • Strong emphasis on training, incident investigation and risk assessments • Manages key risks and thereby decreases the potential for incidents and injuries • Provides the process to manage change • Strong focus on plant and equipment	• Move towards continuous improvement through implementing recommendations from risk assessments and incident investigations • Collaboration between management and workers on regulatory compliance issues • Contribute towards accomplishing an acceptable safety culture • Safety-related incidents are viewed as an opportunity to identify systems failures and therefore improve the system
Weaknesses	**Threats**
• Inadequate employee participation brings about little, if any, frontline 'ownership' • Too systems focused with not enough regard for human factors • Over-reliant on training • Measures lagging indicators -	• Always at risk of becoming a mere paper exercise • An inferior SMS can have a destructive influence on an organization's safety culture, for example when: – Incident analysis creates an air of mistrust and fault-finding – Safety incentive programmes discourage injury reporting – Accountability processes fail to recognize individuals for their accomplishments • The absence of injuries leads many managers to conclude erroneously that people are working safely

Table II

SWOT analysis of BBS processes

Strengths	Opportunities
• Provides a focus on health and safety • Enhance internal goal achievement • Provides the opportunity for a high level of employee involvement • Provides employees with a clear understanding of safe/unsafe behaviour • Uncovers barriers to safe behaviour • Peer pressure acts toward, rather than against safety (and is really peer support) • Utilizes the basic management principle of measurement to realize improvement.	• Create a set of safety rules that are accepted through involvement • Change the worker's poor perception of safety • Set continuous improvement in motion • Get more employees actively involved.
Weaknesses	**Threats**
• Behavioural items that are unacceptable to the workforce are likely to be resented and ignored • Laws of sampling could be disregarded during the data collection process. • Capturing of data often problematic • Schemes tend to focus on types of risks that are easily observable and repetitive. • Quality of feedback depends on commitment of supervisors • Challenging to implement without making use of consultants. Systems that depend on external support time and again fail once the consultants withdraw • The 'no blame' nature of the BBS approach does not deal with the problem of 'continual' offenders who resist peer pressure	• Most unions are likely to resent efforts from management to communicate directly with the employees • The current low level of education of employees may prevent the majority of workers from becoming observers • Supervisors may fail to support the process since the initial change itself is disruptive to their mission • Supervisors may resent the task of observers as unwarranted interference • If management does not reward observers for collecting data, they will stop taking observations • If management does not appreciate good suggestions and ideas, observers will soon tire of offering them.

Occupational safety and health management in the mining industry

Analysis of fatal accidents in the mining industry

The main objective of this part of the investigation was to identify the basic and indirect causes of fatal accidents in mining in order to determine where current safety management systems fall short. A user-friendly systematic investigation technique had been developed to look beyond the errors and violations of individuals by means of examining the contributing factors leading to these occurrences[12]. The aim was to identify local factors and failures within the broader organization and productive system, e.g. training, communication, operating procedures, incompatible goals, organizational culture, equipment, etc., that contributed to the incident. The analysis is bound to incidences in the Rustenburg area of the North-West Region for 2003, as obtained from the national Department of Minerals and Energy.

Information about the age of the deceased, their work experience, the time of the accident, as well as the depth below surface was obtained from the Department of Minerals and Energy. A representative percentage of these accidents (69%) was further analysed by going through the official enquiries into the accidents.

Falls of ground or cave-ins were found to be the highest cause of fatalities, followed by tramming, explosives and machinery. The majority of accidents occurred during the

Figure 6—Proposed integrated safety management system (ISMS)

morning shift when early examination takes place and working places are being made safe. A disturbing fact is that 33% of the fatally injured were in supervisory positions, indicating possible inadequate safety awareness. The average work experience of the fatalities was determined to be approximately 6 years. The least experienced employees are shown to be at highest risk. This not only creates a challenge to expanding mines, but also where medically incapacitated employees have to be substituted, e.g. through the HIV pandemic, which will exacerbate this problem. Attention is also drawn to the increase in risk as employees become more complacent once they have been doing the job for an extended period, i.e. for more than 10 years (see Figure 7).

The root causes of the fatal accidents were determined according to the categories, which are considered in the platinum mining industry:

Compliance (64%)
Compliance and systems (12%), i.e. aspects that are categorized as either compliance issues, or systems issues
Standards (6%)
Systems (18%), which include procedures.

Compliance issues represented about 70% of all the fatal accidents. Systems failures contributed to 24% of the fatal accidents. Standards seem to be better in hand. Although systems failures seem to contributes much less to fatal accidents than compliance issues, it would be prudent to investigate safety management systems in more detail. The safety management system of a specific platinum mine was subsequently audited and the results analysed as a case study.

Analysis of the platinum mine safety management system

The current SMS of the case study mine was evaluated against the proposed formal ISMS[13]. An internal team under the guidance of an external lead auditor conducted the audit. There is an absolutely clear policy that promotes safety and health. It was obvious that a comprehensive hazard review process exists and that hazard controls are in place. Although opportunities are provided for all employees to influence the safety and health programme operation, only a few participate and more employee involvement ought to be encouraged. A higher level of visible management involvement is required to demonstrate commitment. Members of management at all levels should address the safety behaviour of others by coaching and correcting poor behaviour. The reinforcement of good behaviour therefore needs to be given more attention. A safety and health training programme for management does not exist.

Recommendations for successful implementation of the ISMS at the platinum mine

Establishing a culture favourable towards safe behaviour is possible if the leadership within the organization is prepared to embark on a process to change the existing organizational culture. This change process has to be properly managed, because it is often extremely difficult for managers to give up authority and for employees to translate that surrender of power into lasting improvements in quality and productivity. At-risk behaviours, the final pathway to accidents and injuries, are observable, measurable and manageable events. Falls of ground, tramming, explosives and machinery were identified as the most significant risks in platinum mining. At-risk behaviour associated with these key risks should be monitored to provide leading indicators of workplace safety. In addition, a set of rules should be created to deal with each of these hazards.

The mine must actively pursue the identification and removal of barriers to safe behaviour. As stated earlier, system behaviours are driven by consequences. When a workforce routinely engages in at-risk behaviours, one can be certain that the behaviour is being reinforced by naturally occurring consequences that support that behaviour. Those consequences represent barriers to safe behaviour, which generally fall into one of the following eight categories:

Hazard recognition
Disagreement on safe practices

Figure 7—Trend in the work experience of fatally injured employees

Personal choice
Personal factors
Cultural barriers
Ineffective business systems
Inappropriate rewards
Ergonomic barriers.

The existing SMS of the mine is a semi-formal system that evolved over the years. Implementing the ISMS presents the mine with all the advantages of a formal SMS. In addition, it offers a starting point from which to foster greater employee participation. Lastly, it gives the senior management team the opportunity to embrace the most appropriate leadership style to position the mine as a potential leader in the field of safety management in the platinum industry.

Conclusion

To establish safety as a workforce lifestyle and key priority creates a major and exciting challenge to the mining industry. There is strong evidence that organizational culture is a major precondition fostering safe behaviour. Employees are more likely to go beyond their job description if they are satisfied with their jobs, perceive that their supervisors are supportive and considerate, and believe that they are treated fairly by the organization. Effective leaders can inspire their people, and make everybody feel proud to be part of the organization. Creating such a climate involves multifaceted management challenges and excellence across a broad range of skills, and sophisticated organizational support is required to manage the process effectively.

At-risk task related behaviours are the final common pathway for almost all incidents. Safe behaviour alone, however, is not enough. Formal management systems provide the means for an organization to manage and control risks. The best risk management strategy is one that permanently eliminates the hazard rather than relying on worker action to reduce the risk. As a risk management strategy becomes more dependent on procedures, warnings and PPE, its reliability is generally considered to be lower. As this occurs, employee behaviour becomes an increasingly important component of the safety system.

Finally, although the potential value of a proposed integrated safety management system (ISMS) is described in the context of one platinum mine case study to address these conclusions, the true long-term value of such an ISMS must be demonstrated and verified in the mining sector at large.

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