SAFETY IN MINES RESEARCH ADVISORY COMMITTEE

SIMRAC

Final Project Report

Title: FACTORS INFLUENCING THE DETECTION OF UNSAFE HANGINGWALL CONDITIONS

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EXECUTIVE SUMMARY

This project reports on the findings of an investigation into reasons why hangingwall examination procedures fail to prevent fall of ground accidents on gold and platinum mines. Ideally, these procedures should identify every unsafe hangingwall condition and ensure that appropriate action is taken to remedy each unsafe condition.

The examination process is made up of two linked but identifiably separate steps: first, detection of the hangingwall hazard and secondly, hazard remediation. Through an evaluation of this process, the project has identified a range of procedural, environmental, work practice and competence issues that contribute to ineffective examination. It has been established that under good environmental conditions and using existing techniques and equipment with an appropriate emphasis on safety in the workplace, the majority of workers would be able to successfully detect unsafe hangingwall conditions. It has been found that failure to prevent falls of ground is more likely to be related to a lack of resolve to conduct the examination in the first instance, or to remediate an identified unsafe condition. It is suggested that the procedural, work practice and environmental issues identified may contribute to this alleged lack of resolve. The main output of the study is a statement of the priority issues where it is suggested attention needs to be focussed.

A particularly important finding is that the industry's objective over the past 10 to 12 years to have each underground worker accept reponsibility for his own safety, may have compromised rather than improved the situation. By distributing responsibility to all workers, accountability for ensuring the examination is performed effectively, has been diluted. From this study, however, it cannot be said with certainty whether this apparent lack of definition of responsibility stems from confusion over individual roles or is a more deep seated problem.

The project found that workers sometimes criticise the availability or condition of the equipment. None complained, however, about the suitability of the equipment provided. Nevertheless, a number of technologies have been identified which offer an opportunity to improve hazard detection. However, without first addressing the issue of responsibility and other issues identified in this report, there seems little to be gained by pursuing these developments at present.

SUMMARY

In 1995, 2068 fall of ground incidents were recorded on gold and platinum mines and resulted in the deaths of 198 mineworkers and 2031 reportable injuries. The human tragedy of these accidents alone is incalculable. In terms of the numbers, 1995 was not exceptional, fall of ground fatalities and injuries have remained persistently high for many years despite seemingly enormous efforts on the part of all involved to bring about a reduction.

An investigation into the causes of accidents performed for SIMRAC in 1993 (GAP055) found the primary cause of fall of ground accidents (FOG's) to be "inadequate examination, inspection or test". This finding led to the formulation of this project, the objective of which has been to establish why hangingwall examination is not effective in preventing FOG's. The expectation is that an in depth understanding of the reasons will lead to identification of the most appropriate changes in practice to improve the effectiveness with which hangingwall examinations are conducted.

The concepts of "system safety" have been applied, whereby safe production is achieved through "fit for purpose" equipment being used by competent people performing safe work practices in a controlled work environment. A problem in any one component would give rise to poor quality in carrying out the task. An investigative approach has been adopted which would identify the nature of the problem in any one or all of these elements.

A risk assessment conducted with a team from Gold mine X rigorously examined the process of hangingwall examination. This approach led to the identification of a wide range of issues within the mine operation, with the potential to prevent effective examination. The risk assessment process also provided a means of ranking the issues raised in terms of the significance of their impact.

Additional information was obtained from an opinion survey conducted on five mines, four gold and one platinum, in different mining regions. In total 193 mine workers were interviewed. The survey focused on the practicalities of the examination process such as the type and availability of equipment used and environmental influences. Following the findings of the risk assessment, the survey also sought opinions on issues such as responsibility, motivation and willingness to perform the task. The findings of the risk assessment and opinion survey, together with the conclusions, are contained within the main report.

The underground environment where the examination must take place is frequently described as "hostile". The final stage in the project, therefore, reviewed available industry standards on illumination and hearing. This information was studied in conjunction with earlier research reports on the influence of environmental conditions on the performance of underground tasks. Where appropriate, comment has been included in the relevant section of the main report. A fuller explanation of these findings is, however, contained in an

appendix to the report.

In addition, a review of various technologies which could assist in improving the quality of hangingwall examination was undertaken. It was concluded that these technologies would not significantly address the major reasons why hangingwall examination is ineffective, and furthermore, the probability that these technologies would be effective is not considered high by technical specialists. It is considered that at this stage, the major focus should be on the management system, work practices, the underground environment and training.

The major output of the project is the following table which summarizes the main issues which have been found to prevent effective hazard identification and remediation, and proposes approaches through which these issues could be addressed most effectively.

Judgements of need

Description of issue	Judgement of Need	Handled by
Procedural issues		
Responsibility and accountability for hangingwall examination is not clearly allocated to specific job functions.	The statute should be amended to reflect the changes which have occurred during the past decade and more. Specific job categories should be identified as responsible, and therefore accountable, for hangingwall examination.	DME Mines, employee organisations
Processes for mine planning and for drafting standards for hangingwall examination procedures are not participative with the result that they are not practically implementable.	Mine planning should give sufficient attention to the effect decisions have on hangingwall conditions. There should be input from all affected groups under experienced guidance in drafting of standards.	Mines Mines
Bonus systems focus on production, without giving adequate recognition to safety performance.	A culture of "safe production" should be encouraged. Mines should consider the inclusion of safety related components in bonus schemes for all levels of the workforce	Industry, DME Mines
Staff competence issues		
There is a lack of appropriate special physical selection standards for visual acuity or hearing for personnel required to perform hangingwall examination	The appropriate physical standards for eyesight and hearing should be investigated. Selection processes should be implemented for personnel with responsibility and accountability for hangingwall examination.	SIMRAC Mine management, Mine Medical Officers

Description of issue	Judgement of Need	Handled by
There are limitations in current training programmes, with limited "specialist" training for those with specific examination responsibilities, and a tendency towards "learning by rote"	Review training content in the context of theoretical considerations and working environment practicalities. Assess course content with attention to the training requirements for specific job categories.	Mine management, training departments, employee organisations. Mine management, training departments, employee organisations.
First line supervisors, in some cases, are not adequately empowered to fulfil their responsibilities in terms of safety.	Consider the possibility of implementing more rigorous selection processes for appointment of first line supervisors. Develop appropriate training focusing on development of supervisory and motivational skills.	Mine management, training departments, employee organisations. Mine management, training departments, employee organisations.
Environment issues		
Illumination standards are inadequate to permit reliable examination	Development of a practical and cost effective lighting system for use in stopes operating on a drill and blast mining cycle Consider use of portable light sources which significantly outperform cap lamps for hangingwall examination	DME, SIMRAC, research Mines
Environmental conditions, particularly excess heat and noise, adversely affect the ability of mineworkers to fulfil their duties effectively	Research effort should continue to seek ways of reducing ambient temperature levels Initiatives such as the quiet rockdrill should be extended to include fans, pumps, diamond drills etc.	SIMRAC, mines SIMRAC, equipment manufacturers
Work practice issues		
Equipment and materials required to identify and remediate hazards are not always available, especially correct support units.	Review operation and management of stores supply and distribution system on mines. Consider the possibility of designing new adaptable support elements to simplify logistical requirements.	Mines SIMRAC, DME, equipment manufacturers
Labour is not always available to perform examination as often as necessary without compromising production	A culture that safety cannot be compromised under any circumstances should be encouraged	Industry

Description of issue	Judgement of Need	Handled by
Accumulations of broken rock, especially in gullies, prevent adequate hazard identification and remediation	Review loco and track maintenance procedures and implement improvements to the horizontal transport management system to ensure acceptable boxhole cleaning.	Mines
Substance abuse is a problem which results in sub-standard work being carried out	Consider the implementation of systems to prevent workers going underground when incapacitated, and enforce discipline through adequate supervision	Mines
	Consider the possibility of implementing education programmes on drug and alcohol abuse	Mines
Cap lamps do not always provide the standard illumination level	Review existing systems for managing cap lamp condition and implement improvements	Mines

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1 INTRODUCTION

This section of the report summarises the task of hangingwall examination and current strategies used to address the problem. A brief outline is also given of the origins of hangingwall hazards together with a number of reasons why the examination process is not successful in preventing falls of ground. The final paragraphs present a summary of the risk assessment process and the opinion survey.

1.1 Task definition

Several terms and phrases are used to describe the process of detecting unsafe hangingwall. The terms *"barring"*, *"making safe"* and *"early examination"* are some of the terms more commonly used to describe the whole process or a part thereof. The following definition is considered to be reasonably unambiguous, however, and thus satisfactory for current purposes. Simply, the task can be described as:-

the practice of examining the hangingwall using the senses of eyesight, hearing and touch, and equipment, to detect and remedy unsafe hangingwall conditions caused by geological, or mining induced disturbances

Hangingwall examination, in fact, consists of two distinct steps, detection of a hazard and its remediation. It is therefore possible to have a situation where a hazard can be detected but, for one reason or another, nothing is done about it. Detection without correction (or remediation), therefore, serves no useful purpose.

Hangingwall examination is normally performed:-

- at the start of each shift, re-entry after a blast, or after a working place has remained idle for an indefinite period;
- before or during the performance of a task or when moving from one work site to another;
- when experience / training indicate that such an examination is necessary.

The physical requirements of the task are high. Detection of unsafe hangingwall requires the observer to have the capacity to see the target, interpret what is seen and decide on an appropriate response. He may employ one of a number of positional techniques to assist him. For example, his position in relation to the target, the angle at which he illuminates and views the hangingwall, the time spent on a given area and a systematic rather than a random coverage process.

The area to be examined also tends to increase with each blast (unless back areas are effectively sealed off), which often requires considerable travel in an inclined and confined work space. The environment is further compromised by poor illumination, heat, humidity and noise. To assist him, the examiner has only very basic tools: a pinch bar and hammer.

It is common practice for the examination to begin from an established place of relative safety such as the waiting place, the last row of permanent support (development), top of a stope panel, start of a strike gully, etc. On a stope panel it is also practice to work from the top of the panel downwards in the expectation that, should a rock dislodge or be barred down during the examination, it will fall away from the person performing the examination.

1.2 Strategies to address hangingwall hazards

Traditionally, two approaches have been adopted to handle hangingwall hazards. These are (a) prevention and (b) control, either through elimination of the problem or its amelioration. Prevention strategy has focused on obtaining a better understanding of the dynamics of rock behaviour surrounding excavations through research and the development of new, more effective support systems. Control strategies, on the other hand, have sought to implement research findings and support developments while simultaneously seeking to improve operator competence through training. Training is used to provide the mineworker with the requisite knowledge and skills to detect unsafe hangingwall conditions and to take the appropriate steps to remove the danger. It is this latter strategy in particular that is the focus of this report.

1.3 The origins of falls of ground

In order to evaluate any technique employed to detect poor hangingwall conditions, it is considered important to briefly consider the origins of falls of ground.

The rock formations containing the gold and platinum reefs have been subjected to enormous forces since their creation. Among the more visible manifestations of these forces are metamorphism, fracturing, displacement and rolling of the various rock strata. All of these effects are potential causes of falls of ground as they introduced a change to an originally homogenous rockmass. To these may be added intrusions such as dykes and sills. Although by no means a complete list, these features are all indications of a change in rock conditions and, as such, can be used as a means of detecting hazards.

Prior to mining operations, blocks of rock are kept in position by the rockmass. However, mining operations remove supporting rock structures and destabilise the rockmass in general. The mining process itself creates additional dynamic stresses within the rock as faces advance, fracturing the rock and either increasing, reducing or releasing the natural clamping forces between adjacent blocks of rock and the different strata surrounding the excavation. The use of quantities of explosives to break out the reef causes further damage. Falls of ground occur when the gravitational forces acting on blocks of rock (normally in the hanging) exceed the natural (horizontal) clamping forces between them resulting in a block, or blocks, falling into the mined excavation.

1.4 The detection and remediation of unsafe hangingwall conditions

The objective of the detection and remediation process is to take the underground working place from an unsafe state, or potentially unsafe, to one that is safe. This process is presented diagrammatically in Figure 1. Figure 1 also shows us that the hangingwall examination process consists of two distinct activities: the first is detection and the second, correction or remediation of the hazard. In practice, the potential exists for the unsafe state to remain should the hazard detection process fail to detect all possible hangingwall hazards or if remediation fails.

There are essentially three reasons why the examination procedure may fail to achieve its objective adequately. The procedure may be:

- fundamentally inappropriate - even under perfect conditions
  In this case, even if the procedure were to be followed exactly by the most competent operators, the success rate would not be particularly high. In this case there would be little choice but to redesign the procedure, for example by introducing new technology.

- applied by operators without the necessary physical capabilities or job knowledge
  This could be because the training provided is inadequate, or the physical or other personnel selection processes do not adequately cater for job requirements. The solution to this type of problem could be found through offering advanced training, revised selection criteria or procedure redefinition to remove unnecessary complexity.

- ineffective under prevailing conditions - eg. environmental or production pressures
  Procedures are not carried out properly due to practical factors. These could be a wide range of factors such as the environment in which the procedure is to be carried out, priorities established by line supervision or management, problems in materials and/ or equipment supply. Changes to alleviate problems of this nature could be to remove the obstacles which are causing practical difficulties, to modify training to better take into account practical factors, or to amend the procedures in such a way that the practical

factors no longer impinge on the quality of hangingwall examination.

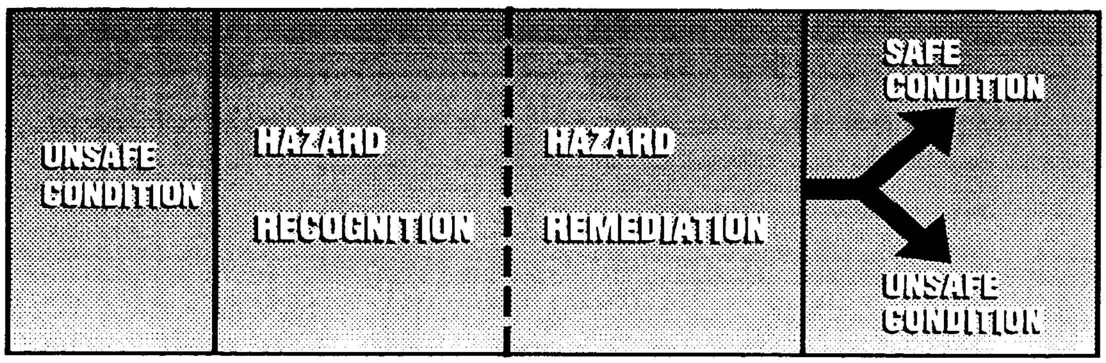

Figure 1 A diagrammatic representation of the steps in the examination process designed to take an unsafe to a safe condition

Ideally, the processes put in place should result in the detection and remediation of every true hazard. Figure 2 presents the examination process diagrammatically: a system of procedures and training designed to ensure 100 percent detection.

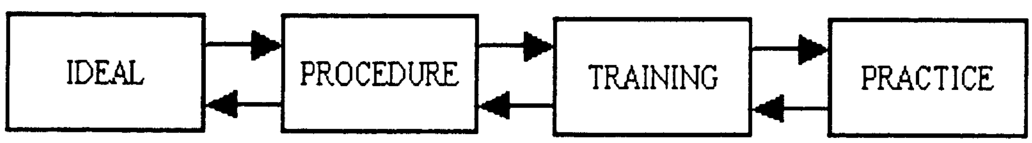

Figure 2 A diagrammatic presentation of the stages of the examination process

In practice, however, gaps occur between the stages, preventing achievement of the ideal. The objective of this project has been to identify where these "gaps" occur and to understand why, so that recommendations can be made to more closely align underground practice with the ideal situation.

1.5 Risk assessment

A risk assessment exercise was performed to identify the underlying factors which inhibit or prevent the detection and remediation of unsafe hangingwall conditions. The participative nature of the risk assessment allows the accumulated knowledge and experience of all those involved, including managers, miners, operators and technical experts, to focus on the issues.

The risk assessment involved a team of production and support staff at Gold mine X. The team was required to subdivide the hangingwall condition monitoring process into stages, beginning with the origins of the problem through to the detection of unsafe hangingwall conditions. At each stage they were required to identify ways in which the hangingwall condition monitoring process could fail, as well as the measures in place to reduce the chance of such failures. Next, an assessment was made of the probability and likely consequence of each failure to identify or remediate hazards (the risk), and to rank risks according to a common scale. Where appropriate, the team made recommendations to correct identified shortcomings. The exercise focused on the situation at Gold mine X but the findings are believed to be representative of the broader gold and platinum mining industry.

A report on the risk assessment is included as Appendix 1.

1.6 Opinion survey

The opinion survey interviewed 193 workers and supervisors on five different mines. The survey consisted of thirty-eight questions pertaining to the ability to detect and remediate unsafe hangingwall, considering such factors as the equipment used, training received, environment, frequency and responsibility for the task. Responses were evaluated according to job category, experience, training and mine.

A summary of the opinion survey is included as Appendix 2.

The risk assessment produced a large amount of information on procedures believed to be common to gold and platinum mining operations, and the underlying thought processes leading to the definition of these procedures. On the other hand the opinion survey focused on the practices, perceptions and opinions of a large group of underground workers. Both approaches addressed the same problem but from different ends. The outputs of both exercises have been combined in the following sections as the findings. Where possible an interpretation of each finding is given in the context of the detection and remediation of unsafe hangingwall conditions.

1.7 Issues identified

The risk assessment and opinion survey identified a range of issues which impact upon the detection and remediation process. In total, perhaps, the process identified more than 30 issues ranging from those requiring immediate attention to the less important. The significance of each issue is reflected in the ranking accorded to it by the participants. The evaluation and interpretation have been provided by CSIR, Mining Technology.

Identified issues are grouped under the different headings: procedures, training, environment and practice. These are only loose groupings as there is no clear distinction between what constitutes a particular type of issue and, in several instances, an issue could be placed in more than one category.

2 PROCEDURES

Procedures govern the way in which available resources are applied to achieve a desired objective. The following section records issues of a procedural nature identified as influencing the successful detection of unsafe conditions.

2.1 Responsibility for hazard identification

An important finding of the risk assessment is that the task of detecting unsafe hangingwall conditions is the responsibility, stated or implied, of more than one and sometimes several job categories. This is in addition to the legal responsibility of the appointed miner. This finding came up again during the opinion survey and both findings are presented here.

Table 1. <u>Personnel responsible for detection of unsafe hangingwall conditions</u>

PERSONNEL RESPONSIBLE FOR CONDITION							TABLE 1
	Rock/ Geol.	Prod Manager	Mine Overseer	Shift Boss	Miner	Team Leader	Operator
Geology - Fault			▲	▲	▲	▲	▲
Dyke			│	│	│	│	│
Slip			│	│	│	│	│
Water			│	│	│	│	│
Previous Fall			│	│	│	│	▼
Rock Type			│	│	│	│	
Channel Width			▼	▼	▼	▼	
Mining - Layout	♦	♦	▲				
Layout execution			│	▲			
Face Shape			│	│	▲	▲	
Drill Blast			│	│	│	│	
Support			▼	▼	▼	▼	

Table 1 presents the team's assessment of who is responsible for detecting the various geological and mining indicators of poor hangingwall conditions. The table summarises the team's opinion that there is a shared responsibility for this task. For example, detection may be the responsibility of the team leader who should decide on the remedial action. His decision may subsequently be supported or a further instruction given by his superior: the miner, shiftboss or mine overseer. Where split responsibility exists, it is likely that each individual in the chain of command will expect his decision not only to be scrutinised but possibly countermanded. Can he therefore be expected to take ownership? If there is abrogation of responsibility on the part of anyone for this task, it is worth remembering that, historically, mines appointed one or more workers on each gang to "bar" the hangingwall. Although responsible to the miner in charge and his team leader, it was the intention that "barring" the hangingwall and testing for loose rocks should form his principal activity. The impact of the decision to move away from designated tasks for each job category towards multi skilling cannot be judged. However, its possible impact on responsibility and accountability should not be ignored.

In the opinion survey, interviewees were asked to respond to the question "who should be responsible to do the hangingwall examination".

In response, 79 per cent stated that everyone underground should be responsible and only 3 per cent said that this was not the case. Broadly speaking, the reasons given for everyone underground not taking responsibility were that "people couldn't be bothered", or that everyone thought it was someone else's job.

Table 2 summarises the job categories perceived to be responsible for this task together with the percentage of respondents, as recorded by the opinion survey.

Table 2 Job categories considered responsible for examination of the hangingwall

Group/ Individual	Should be (Y/N)	Percentage	Normally the case	
			Yes (%)	No (%)
Everyone underground	Yes	79	76	3
Team leader	Yes	44	42	2
Miner	Yes	25	24	1
Shift boss	Yes	12	11	1
Mine Overseer	Yes	7	6	1
Pinch bar user	Yes	2	2	-
Winch driver	Yes	1	1	-

Results from different mines varied considerably. Staff at Mine No. 1 inclined much more than others towards having definite authority figures carrying responsibility. The favourite was the Team

Leader. Of those with more than 10 years experience, 79 per cent felt that everyone underground was responsible with 43 per cent recommending the Team Leader as their second choice. Overall, 44 per cent of candidates considered it to be the Team Leader's and 25 per cent the miner's responsibility. Somewhat surprisingly among the miners, 78 per cent agreed it was everyone's responsibility, 39 per cent the Team Leader's and only 35 per cent stated it was their own responsibility. Although the miner holds legal responsibility, his position behind "everyone" and the Team Leader can be explained by the fact that the others generally arrive at the working place before the miner and those empowered in terms of working "concessions". The general view expressed possibly embodies the approach mines have adopted for about 10 years, ie. that "everyone underground" should take responsibility for his own safety.

2.2 Responsibility for hazard remediation

It has already been stated that the detection of unsafe hangingwall conditions is the first step in a two step process of detection and remediation, and interviewees were asked to state who was responsible for remediating identified hazards. The responses are summarised in Table 3.

Table 3 Job categories considered responsible for remediation of unsafe conditions

Group/ individual	Should be (Y/N)	Percentage	Normally the case	
			Yes (%)	No (%)
Miner	Yes	54 (25)	53	1
Team leader	Yes	53 (44)	51	2
Everyone underground	Yes	52 (79)	50	2
Shift boss	Yes	39 (12)	37	2
Mine overseer	Yes	24 (7)	22	3
Winch driver	Yes	1 (1)	1	
Safety representative	Yes	1 (1)	1	
Pinch bar user	Yes	1 (2)	1	

Note: the figures in brackets are the percentage considered responsible for detecting unsafe hangingwall.

There appears to be little correlation between the job category considered responsible for detection and that responsible for remediation. Those who gave reasons for a difference in their answers stated, for example, that the shift boss and mine overseer were often not present at the time. Other comments concerned the knowledge, or lack of it, of the team leader and miner and the lack of responsibility of "everyone".

Discussion

It would appear that the message of everyone being responsible may have been misinterpreted. This observation is prompted by the considerable difference between a general principle that each individual should be aware of the many hazards underground and a policy that makes him responsible for their detection and remediation. The probable outcome is that no individual or group actually accepts responsibility for this specific task. For optimum performance, the detection of unsafe hangingwall requires certain skills and physical attributes which are the result of specific training and experience. At present, the task appears to have been relegated to one that, "anyone can - and should do it", rather than one that enjoys the high level of attention that it deserves. The following analogy should emphasise this point.

A worker in a chemical plant, whose job does not normally expose him to dangerous chemicals, etc. will receive specific training for his own tasks, coupled with a general instruction not to venture into identified areas, or to try and perform a particularly hazardous task. He is reminded that a group of people have been *specially trained* to handle hazardous chemical accidents.

This does not appear to be the case in the detection and remediation of hangingwall hazards where all workers are ostensibly required to detect unsafe conditions and maybe remediate an unsafe condition, regardless of whether they have the necessary training, knowledge or experience.

The risk assessment found a pressing demand for workers to be made accountable (level 1 of importance on a qualitative scale of 1 to 25). In other words there is little point in saying that everyone is responsible for hangingwall examination, when "everyone" is not held accountable. This comment applied equally to the detection of a hazard and its remediation. The disciplinary policy was not considered to be effective in dealing with those who failed to perform satisfactorily.

2.3 Bonus system

Bonuses are used to motivate workers to achieve a desired level of performance in a particular activity. In the case of Gold mine X, the bonus scheme was considered to fail because it did not achieve its combined objectives of safety and production. Its high ranking (level 1 importance), appears to imply that, alone, the potential hazard which unsafe hangingwall represents is insufficient motivation to convince workers to perform the task. Historically, mining companies used bonuses to improve production performance among key personnel, eg. miners, machine crews, team leaders. Mining teams also received rewards for good safety records. Until fairly recently, however, the shiftboss was probably the only person with a safety component in his bonus, because he was deemed accountable for his team's safety record. This policy has changed in recent years to one where most stope / development team members now share in the production bonus. In addition, safety is included as a component in team leaders bonuses.

If the problem is lack of motivation, or willingness to perform the task, it does not appear to have been successfully addressed by the bonus system. Perhaps the solution lies in a further change to the bonus system or training methods that might create the motivation to do something about the hangingwall hazard.

2.4 Inspection techniques

The most frequently used inspection techniques are visual (91 per cent), sounding (87 per cent), barring (63 per cent) and watering down (31 per cent). Although important to all experience groups, visual inspection was only the most frequently mentioned technique for those with more than ten years experience.

The importance attached to sounding as an examination technique is significant as high levels of external noise will interfere with performance. Seven per cent of officials interviewed said that sounding was not done.

The risk assessment produced a list of very reliable geological and mining indicators of poor hangingwall conditions. The reliability of the various features as indicators of poor hanging given by the team, together with those believed responsible for their identification, is presented in Tables 4 and 5.

Table 4 Reliability of various geological features as indicators of hangingwall hazards

GEOLOGICAL FACTORS			
FACTOR	RELIABILITY AS AN INDICATOR	CRITERIA	RELEVANT PERSONNEL
Faults	1*	Brow/ plane	MO to Operator
Dykes	1*	Colour change - drilling	MO to operator
Water	1*	Wet/ dry	MO to operator

GEOLOGICAL FACTORS			
FACTOR	RELIABILITY AS AN INDICATOR	CRITERIA	RELEVANT PERSONNEL
Reef geometry	1*	Change in thickness and dip	MO to Team leader
Previous FOG's	2*	Visible parting - can't bar - sounds hollow	MO to Team leader
Rock type eg. shale etc.	5*	Different colour - structure	MO to Team leader
Slips (note interaction)	9 (6*)	Inconsistent plane, fractured	MO to operator
Feather wedging	14		MO to operator
Cross bedding	18		
Changes in strata thickness	24		

* denotes a critical area

The reliability number indicates the team's belief that these geological indicators are not only good indicators but also fairly easy to observe. The recommendation is that those indicators with a reliability better than 11 should be used in training those whose job it is to examine the hangingwall.

Table 5 presents the team's list of mining induced indicators of poor hangingwall together with the individuals considered responsible for identification.

Table 5 Reliability of mining factors as indicators of poor hangingwall conditions

MINING FACTORS			
FACTOR	RELIABILITY AS AN INDICATOR	CRITERIA	RELEVANT PERSONNEL
U/g layout plan v. work plan	1*	Multiple hangingwall related characteristics and issues	Rock mechanics engineer to MO
Drill & blast	1*	Sockets in Hangingwall ; hole alignment; overcharging; incorrect burden or hole pattern	MO to Team leader
Support	1*	Blasted out; not installed to standard; missing	MO to Team leader
Face shape	1*	Corners; lagging; no sidings; poor/ difficult cleaning	SB to Team leader
Cleaning	1*	*Indicative of above problems only*	
Layout control U/g	15	Faces leading - out of sequence	MO to SB

* denotes a critical area

It is clear from Tables 4 and 5 that there are at least 12 very reliable indicators of hangingwall hazards. These should form the basis of training, if they do not already, for the relevant personnel as identified in the tables.

2.5 Participation of all parties in drafting support standards

The use of a participative approach was recommended when drafting support standards (level 4 importance). Similarly, it was recommended that planning meetings should include the participation of an experienced mine overseer (level 7 importance), whose specific responsibility would be to ensure that hangingwall conditions continue to receive high priority, and that those responsible for carrying out procedures were made aware of relevant decisions.

These findings suggest that the present system for drafting procedures is failing to meet the objectives and, as a result, hangingwall examination is not receiving sufficient attention. The recommendation to use an experienced mine overseer for this role would support the need for a combination of practical, local experience in the development of the revised standard procedures.

In the opinion survey, 96 per cent stated an examination code of practice existed on the mine and that they knew it, and 93 per cent stated that they always applied it. By workgroup, 92 per cent of workers said a standard existed and that they had received hazard identification training. In contrast, 10 per cent of workers stated that they did not know and understand the standard. More surprising, perhaps, was the statement by 14 per cent of officials that "they" only applied the code/ standard sometimes.

Training procedures need to be reviewed to determine why an apparent 10 per cent of workers do not know the standard. The review should also assess why people are unwilling to apply practical procedures of examination and support.

2.6 Summary - Judgement of Need

The findings from Section 1 are summarised in Table 6 which presents the primary issues in order of importance and the group(s) believed most appropriate to handle the issue.

Table 6 Judgements of need relevant to procedural issues

Order	Description of issue	Judgement of Need	Handled by
1	Responsibility and accountability for hangingwall examination is not clearly allocated to specific job functions.	The statute should be amended to reflect the changes which have occurred during the past decade and more.	DME
		Specific job categories should be identified as responsible, and therefore accountable, for hangingwall examination.	Mines, employee organisations

Order	Description of issue	Judgement of Need	Handled by
2	Processes for mine planning and for drafting standards for hangingwall examination procedures are not participative with the result that they are not practically implementable.	Mine planning should give sufficient attention to the effect decisions have on hangingwall conditions. There should be input from all affected groups under experienced guidance in drafting of standards.	Mines Mines
3	Bonus systems focus on production, without giving adequate recognition to safety performance.	A culture of "safe production" should be encouraged. Mines should consider the inclusion of safety related components in bonus schemes for all levels of the workforce	Industry, DME Mines

3 COMPETENCE OF STAFF

3.1 Training

A training programme should provide workers with competence, in the form of knowledge and skills, to perform the task of detecting and remediating unsafe hangingwall conditions. As previously mentioned, this task is of such importance that it is general policy on mines to teach everyone from novices onward the basics of detection. Workers are also taught to begin each activity with an examination of the hangingwall. Following the period of induction training, the worker is expected to have a general awareness of the hazards and the action to be taken when a hazard is detected.

The risk assessment found the selection of supervisors, training in proper job instruction, and following up on instructions all to be "level 1 importance" issues. The opinion was also expressed that supervisors should receive special training on teaching workers to identify hangingwall hazards, ie. pass on their knowledge, and, secondly, how to remediate particular types of hazard (level 1 importance).

Other competence related recommendations were that training should be performed in underground conditions (level 2 importance). (Note: the present investigation into the use of "virtual reality" techniques is not seen as being in conflict with this finding. Rather, that virtual reality will be used as a teaching aid, at a novice, intermediate, or possibly refresher stage.)

Training aids such as models and cards to get the message across were highly recommended (level 3 importance). Misunderstandings as a result of poor verbal communication between supervisor and worker was considered to be a serious drawback (level 3 importance). It was suggested that linguistic ability should form one of the selection criteria for supervisors (level 4 importance), and that everyone should be able to understand English. An inability to describe in the vernacular the action to be taken when a particular hazard is identified, may also be a contributing factor to poor discipline. By contrast, the opinion survey only recorded two claims that poor communication had a role in the examination. (It must be stated, however, that interviewees gave spontaneous responses about what were considered to be the major reasons why the examination process was not as successful as desired.)

By their recommendation that all levels, up to and including mine overseer, should undergo training in hangingwall condition monitoring (level 4 importance), the risk assessment team recognised the need for ongoing refresher training and education.

Lack of training or knowledge was cited as the reason for examinations being ineffective by 22 per cent of respondents in the opinion survey, and 29 per cent gave it as a reason for failing to remedy identified hazards. These high percentages suggest that either workers are unable to understand or remember what they are taught or that training methods are at fault.

In order to test job knowledge, the opinion survey included a number of questions which permitted assessment of the ability of respondents to identify hazardous conditions and to select appropriate remediation measures.

3.1.1 Hangingwall hazard recognition

Ideally, underground workers should detect every unsafe hangingwall condition. In practice, human and environmental constraints result in the performance of this task being less than optimal. The question that remains, however, is how well workers are actually able to perform the task underground.

In order to establish workers' optimum detection performance under "ideal" conditions, candidates were asked to study a series of 21 photographs depicting a selection of hangingwall hazards. Photographs were selected by an expert in rock mechanics as being representative of common hangingwall hazards found on gold and platinum mines. With the exception of one mine, candidates were able to view the photographs on surface and under normal illumination, ie. under conditions of good visibility and low stress.

Five photographs depicting "stable" hangingwall conditions were included at random amongst the 21 to forestall any attempt to claim that all the photographs depict unsafe conditions. The photographs are shown in Appendix 3 together with "expert" opinion on the type of hazard identified. The appropriate remedial steps are also provided.

The percentage of candidates correctly identifying the hazards ranged from a low of 76 per cent to a high of 96 per cent, although the percentage detection varied according to mine, job category and experience. This would indicate, that, without the negative influence of the underground environment, the majority of candidates are able to correctly identify an unsafe condition underground.

Among the selected groups, it was observed that a greater percentage of officials and blasting ticket holders (miners) agreed with the expert's assessment than did supervisors or workers. Educational standards for each group were not recorded so this possible influence is unknown. However, it is postulated that, when uncertain, officials and miners might tend to err on the side of caution, and, in support of this explanation, several officials and miners identified a hazard in photographs ostensibly depicting "stable" hangingwall conditions.

Another example of response variations between different job categories is given by a study of responses to photographs 3, 7, 11, 12 and 17, all of which are deemed to depict "stable" hangingwall conditions, (ie. no identifiable hazard and therefore no action required).

For example, on Mine No. 2, photograph No. 7 was deemed to depict a hazard by 82 per cent of candidates. On Mine 3, 86 per cent of candidates stated that photograph No.12 depicted a hazard. On Mines No. 4 and 5, 76 per cent and 95 per cent of candidates respectively claimed that photograph No. 17 depicts a hazard. This response is considered unsatisfactory because, if every condition is declared unsafe, it implies that considerable time and effort are being wasted on correcting safe conditions.

However, this exercise demonstrates that, under "ideal" conditions, the majority of underground workers are able to detect unsafe hangingwall conditions. Underground, it is expected that these percentages will be somewhat lower as a result of poor environmental conditions.

3.1.2 Methods used to remediate hazards

Ninety-two per cent of people interviewed stated that an identified hazard should be supported, 84 per cent said it should be barred down and 27 per cent that it should be fenced off. Reporting the hazard was important to less experienced workers (< 5 years). When asked specifically how they would remedy a fault or a slip, a third appeared not to know the hazard. Sixty-seven per cent of novices suggested reporting the hazard and , among those with more experience, this percentage fell to between 2 per cent and 4 per cent.

When asked what should be done if a hazard cannot be remedied properly, 79 per cent said it should be fenced off and 74 per cent said that it should be reported to the team leader or miner. Twenty-three per cent said that an alternative remediation measure should be applied.

These responses indicate that many workers believe they are capable, either through experience or training, of dealing with a difficult condition. However, if they cannot deal with the problem, we must be certain that their supervisors can provide a safe solution.

3.2 Selection of supervisors

The role of the supervisor (team leader, miner and shiftboss) was viewed as very important (level 1 importance) and that in certain cases individuals were not performing as well as they should. The principal reason for this situation can be summarised in a word, empowerment. It was stated that a number of supervisors (and certainly more than acceptable) lacked the ability to motivate subordinates, use initiative, and failed to report particularly poor hangingwall conditions to their own supervisor.

These comments suggest that training, and particularly supervisor training, is an area that requires constant review. It is highly improbable, however, that training methods can accommodate every conceivable variation in hazard condition. This can only be addressed by ensuring that supervisors are knowledgeable of as many conditions as is practicable and receive the best training possible. The introduction of basic theory in geology and rock mechanics to team leaders on some mines is a good example of efforts to provide first line supervisors with additional knowledge as well as skills.

The team considered that supervisor selection criteria should be more stringent and should specifically include length of experience and, particularly, safety performance.

The measure of any training programme is the performance of the trainee upon return to his section. When training programmes for this task are reviewed, those responsible must be satisfied that suitable selection criteria are in place and practised, training is focused and competence properly assessed.

The risk assessment referred to the fact that "human error" can be traced to selection criteria, standards, training content and methods employed, competency testing and performance monitoring. Here the team clearly states that all these issues need to be thoroughly reviewed. The debate is not about whether standards may have slipped, or even improved. The statement made is that performance will not improve unless supervisors are as competent as they possibly can be.

3.3 Physical selection

The project proposed to investigate certain aspects of the physical fitness, or competence, required to perform an examination, eg. eyesight, visual acuity. Only one interviewee (0,5 per cent) however, considered the physical condition of the examiner to be a contributory factor to problems with the examination. In contrast, poor visibility caused by lack of illumination, water vapour and dust was considered a problem by 96 per cent of those interviewed.

Although the risk assessment recognised the need for the examiner to be able to see properly, his overall physical condition was not raised as a factor. The project has, however, reviewed information on the importance of physical fitness to this task, and endeavoured to learn from other research studies the levels of eyesight and hearing proficiency required. A summary of the findings of this investigation are presented here. The main investigation is reported in Appendix 3.

3.3.1 Visual acuity

Visual acuity has been described as the ability to see detail.

Research shows that ambient levels of light underground do not adversely affect visual acuity and thus should not compromise worker safety. Nonetheless, the visual performance required to perform any task depends upon several factors including peripheral vision, colour vision and visual acuity. The need to be able to detect geological features during examination and recognise bad mining practices has already been recognised as important by the risk assessment. It therefore seems reasonable to assume that a degree of visual acuity is important.

Visual acuity is dependent upon luminance (both far and near vision), colour of the light flux, contrast, glare and, where necessary, corrected vision (ie. the wearing of spectacles). Underground, it has been shown, none of these influences reaches a satisfactory level. Environmental conditions make the wearing of spectacles in the predominantly humid conditions irritating. In response to a general question about major problems with the examination, three persons (1,5 per cent) stated poor eyesight. Apart from this last comment, however, it would appear that workers believe they are able to see well enough to perform an examination.

Surface treatment to enhance identified unsafe hangingwall hazards, such as faults and brows, with coloured paints is an established practice. However, a surface treatment to assist the examiner to detect an unsafe condition has yet to be developed.

Techniques to improve the reflectance of the rock surface, and thereby increase the contrast between the target and its background, appear to be limited to the use of water whose primary benefit is the removal of dust.

3.3.2 Hearing

"Sounding" the hanging (the practice of striking the rock with a steel "pinch" bar or hammer) produces a sound whose frequency is dependent upon factors such as the thickness of the rock, its density, dimensions, and mode of attachment to adjacent blocks as well as the quality of steel used. This frequency is estimated to lie in a range between 200 Hz and 1500 Hz. It seems reasonable to assume, therefore, that the examiner's hearing threshold must be such that he is able to hear properly at the lower frequencies. The risk assessment considered lack of a selection process to ensure that workers with acceptable hearing thresholds was a moderate risk, (level 11 importance) and recommended that the hearing threshold and frequency response required to "sound" the hanging be investigated, considering the environmental noise levels within which examination is carried out.

3.4 Summary - Judgement of Need

This section has addressed the issue of the competence of the examiner in terms of the physical requirements and level of knowledge and skill. Although it did not come out in the study, it is suspected that training workers to examine the hangingwall has become too routine. To correct this, those who conduct examinations need to be chosen carefully, properly trained and managed. Table 7 lists the most significant issues requiring attention.

Table 7 Judgements of need relevant to operator competence issues

Order	Description of issue	Judgement of Need	Handled by
1	There is a lack of appropriate special physical selection standards for visual acuity or hearing for personnel required to perform hangingwall examination	The appropriate physical standards for eyesight and hearing should be investigated. Selection processes should be implemented for personnel with responsibility and accountability for hangingwall examination.	SIMRAC Mine management, Mine Medical Officers
2	There are limitations in current training programmes, with limited "specialist" training for those with specific examination responsibilities, and a tendency towards "learning by rote"	Review training content in the context of theoretical considerations and working environment practicalities. Assess course content with attention to the training requirements for specific job categories.	Mine management, training departments, employee organisations. Mine management, training departments, employee organisations.
3	First line supervisors, in some cases, are not adequately empowered to fulfil their responsibilities in terms of safety.	Consider the possibility of implementing more rigorous selection processes for appointment of first line supervisors. Develop appropriate training focusing on development of supervisory and motivational skills.	Mine management, training departments, employee organisations. Mine management, training departments, employee organisations.

4 ENVIRONMENT

4.1 Illumination

The risk assessment considered illumination in terms of whether a cap lamp provides enough light to examine the hangingwall properly. The team considered illumination of moderate importance (level 11 importance), implying that they considered it to be sufficient. This is not believed to imply, however, that improved levels of illumination would not result in increased hazard detection.

The opinion survey found that poor illumination caused everyone (96 per cent) problems with hazard detection and remediation. The principal implication of these findings is that workers would appear to be able to detect hangingwall hazards, even in prevailing light conditions. Secondly, workers appear to accept low levels of illumination as a constraint within which they are required to operate.

Visibility was considered to interfere badly with hazard detection (level 3 importance). In the opinion survey, 96 per cent of those interviewed also stated that poor visibility interfered with hazard detection. As we know, methods exist to address the causes of poor visibility (saturated air, low air velocities and dust). However, both the risk assessment and the survey results indicate, that despite the interference created by poor visibility, it does not prevent the examiner from performing effectively, (except under exceptional conditions).

Underground additional lighting is required at tips, shaft stations and where moving machinery is erected (hoists, pumps etc). If we consider, the "fixed" nature of the dangers presented by these facilities, it appears somewhat inconsistent that adequate and effective lighting is not required for the "dynamic" nature of the dangers associated with hangingwall examination. Experience of mechanised mining with higher ambient light levels suggests that there is a general improvement in the level of awareness of the surroundings. Is it, therefore, enough to say that the dynamic nature of the process prevents the use of better lighting?

A recommendation has been made previously for an investigation into the lighting requirements for various underground tasks.

4.2 Noise

The risk assessment considered noise to be a moderate risk (level 11 importance). A similar finding was given by the opinion survey where 53 per cent of those interviewed considered high noise levels to interfere with hazard detection. The reasons given were that they were unable to hear the rock "talking", and that it was distracting. Those with less than one year's experience or those with 2 - 5 years experience appeared to be the most affected. Officials, as a group, were most affected, probably because they are not generally exposed to noise for lengthy periods.

4.3 Temperature and humidity

Fifty-nine per cent of those interviewed felt high temperatures were a problem in hazard identification and remediation. The reasons given were that high temperatures caused fatigue and lack of concentration, irritability and impatience. Heat and humidity appear to affect those in higher job categories more than the others. Again, the reason for this is assumed to be that these groups are less well acclimatized.

4.4 Confined workings

Physical and postural constraints are more common in stopes than development ends. However, only 30 per cent of underground workers consider confined workings to be a problem. Dissatisfaction with confined workings was found to be higher among novices and appears to peak after about five years experience, after which it would appear to become less important. Unfortunately, the percentage of interviewees familiar with steep workings was not established and it is possible for this figure to be somewhat higher.

4.5 Steep workings

Similarly, hangingwall examination in steep workings is considered a problem by 35 per cent of workers. Reasons given included poor footing and concerns about the danger of rolling rocks caused by barring operations. Eighty-six per cent of officials considered steep dips to affect task performance compared to only 20 per cent of workers. Again, subjects were not asked whether they had experience of steep workings.

Although clearly important, the geometry of the workings is a factor beyond the control of the examiner. However, he should be aware of the limitations that these conditions may place on him and, for example, allow as much time as necessary to perform the examination.

4.6 Summary - Judgement of Need

It is suggested that the medium ranking given to the various environmental conditions is somewhat misleading. (For example, the ambient light levels in stopes are between 5 per cent and 10 per cent of the minimum required, by law, over conveyors on surface). Although indications are that workers are able to see in these low levels of illumination, it should not be taken to imply that these levels are acceptable. A similar comment applies to ambient noise levels. It is not believed to be necessary to wait until the effect of these influences has been formally established before effort is made to alter the environment to suit man. Being able to cope is not enough.

Past research has focussed on the productivity effects of high working temperatures. Little research has been conducted into the effects of noise, high temperatures and humidity on cognitive ability. The development of a quiet rock drill needs to be followed by similar initiatives to reduce mechanical noise levels from other sources and to increase illumination in the workplace.

The constraints placed on the examination process by the geometry of the workplace do not appear to present a problem.

Table 8 Judgements of need relevant to environmental issues

Order	Description of issue	Judgement of Need	Handled by
1	Illumination standards are inadequate to permit reliable examination	Development of a practical and cost effective lighting system for use in stopes operating on a drill and blast mining cycle	DME, SIMRAC, research
		Consider use of portable light sources which significantly outperform cap lamps for hangingwall examination	Mines
2	Environmental conditions, particularly excess heat and noise, adversely affect the ability of mineworkers to fulfil their duties effectively	Research effort should continue to seek ways of reducing ambient temperature levels	SIMRAC, mines
		Initiatives such as the quiet rockdrill should be extended to include fans, pumps, diamond drills etc.	SIMRAC, manufacturers

5 WORK PRACTICES

5.1 Substance abuse

Substance abuse is found in almost all industries today. In respect of this task, the risk assessment team clearly considered it a problem, breaking down discipline and weakening the resolve or ability to perform effectively. The team considered it to be a high priority (level 3 importance). In the opinion survey, interviewees were not asked to comment on whether they thought substance abuse was a problem.

There appears to be no easy solution to this social problem. Perhaps the best that can be achieved is some measure of control over its use in the workplace. A suggested approach is to review existing procedures used to handle users together with appropriate behaviour reinforcement to try and curtail the use of alcohol and drugs.

5.2 Loco and track maintenance

Accumulations of broken rock was the main reason cited by the risk assessment team for failing to detect poor hangingwall in the vicinity of strike gullies (level 3 importance). Implicit in this statement is that the area couldn't be examined properly until it had been cleaned. It was therefore examined superficially or not at all. By association, the area was therefore poorly supported. In this particular instance at Gold mine X, the problem was traced to locomotive breakdowns and train derailments preventing the gullies from being properly cleaned.

It could be claimed that locomotive breakdowns reflect the normal mining versus engineering syndrome. Alternatively, the team is saying that "we are trained and instructed to examine the hangingwall, particularly in the gully area. However, you (management) do not ensure that the examination can be performed properly because of locomotive breakdowns and full gullies. Yet we are still expected to examine perfectly".

As a reason for ineffective examination, inadequate cleaning of the working place was cited by only 3 per cent of those interviewed in the opinion survey. Again, the difference is probably explained by particular problems on that mine.

5.3 Availability of equipment and materials for examination

Ninety-seven percent of candidates stated the need for a pinch bar, 79 per cent, a 2 kg hammer and 33 per cent, water (for washing down). The overall order of usage was similar across all job categories except miners, 39 per cent of whom required a methanometer. This reflects some confusion over use of the term "examination". It is seen as a term embracing a number of tasks of which hangingwall examination is only one.

Workers complained the most about non-availability of equipment, although only a small percentage (2 per cent to 3 per cent). Most complaints came from Mine 1, although again only 3 per cent to 6 per cent respectively. These percentages are considerably lower than 15 per cent who gave lack of equipment or materials as the reason for ineffective examination and not remedying identified hazards. No reason can be given for this difference.

The condition of pinch bars was generally good, with 88 per cent stating that they were normally sharp and 66 per cent that they were the correct length. The greatest concern was for a hand guard, with 91 per cent stating that this was normally in place.

The risk assessment had serious concerns (level 1 importance) about the systems in place to ensure delivery of the correct supports to the right workplace, which prevents compliance with support standards. Whether the problem is one of low stock levels, the distribution or delivery system to the underground workings, the team appears to be saying: "the standards are correct, we are properly trained and will apply them but cannot, because the mine is unable to provide enough supports of the right type". Implicit in this response is that the workforce is unable to remedy unsafe conditions and thus prevent falls of ground.

The opinion survey records that 15 per cent of those interviewed considered that a shortage of equipment (pinch bars, etc.) prevented them from effectively detecting unsafe hangingwall conditions. A similar percentage stated that lack of materials caused problems when remediating identified hazards. (The difference between the findings of the risk assessment and opinion survey is attributed to the fact that particular problems were being experienced at Gold mine X at the time the risk assessment was performed.)

It can be argued that both these findings are simply excuses for poor performance. However, if one sixth of the workforce perceives this to be the true situation, action needs to be taken to correct it.

5.4 Cap lamps

A medium priority finding of the risk assessment (level 11 importance) was that an excessive number of cap lamps provide lower illumination levels than they should. It was suggested that a method be developed to screen lamps to reduce the number of dim lamps underground. In the opinion survey only 20 per cent of candidates answered a question asking them to state the equipment required to perform an examination. It is assumed that the other respondents considered a cap lamp an obvious item. Of the 20 per cent, 3 per cent stated that their lamps were not bright and fully charged. Again, the comment can be made that workers have become so used to the levels of illumination underground that they find it difficult to visualise improvements. Poor illumination, however, was not given as a reason for ineffective examination in the general section of the questionnaire.

5.5 Labour shortages

Labour shortages were given high priority (level 1 importance) by the risk assessment. It was stated that labour shortages commonly arose from absenteeism, illness and accident. However, in the opinion survey, only 1,5 per cent of those interviewed said labour shortages affected the examination.

Seventeen per cent of respondents gave production pressure as the reason for not doing an effective examination, and 19 per cent said it was why identified hazards are not remedied. Labour shortages result in certain tasks taking precedence, while others may be done in part or not at all. The implication of the high ranking of labour shortages in the risk assessment is that "other" tasks are considered to have priority over that of detecting unsafe hangingwall. What is being said is that if a series of activities, say the stoping process, requires a specific number of workers, and only a certain percentage is available, for whatever reason, then the reduced number cannot be expected to deliver effectively on every task.

5.6 Frequency of examination

Candidates were asked to state how often an examination should be performed. Overall, 76 per cent stated that examination should be done continuously; 56 per cent that it should be done at the start of every shift and 19 per cent that it should be performed at regular times throughout the shift. When questioned about whether workers followed procedures as was claimed, the majority stated that they did.

By job category, 86 per cent of officials said that examinations should be done continually, although 14 per cent said this did not happen. Surprisingly, only 29 per cent of officials stated that the examination should be performed at the start of the shift, compared to 67 per cent of workers. No explanation was forthcoming for this finding.

Although there was considerable variation in responses between mines, Mines 3 and 5, specifically, asserted the need to perform examinations continually (91 per cent and 93 per cent respectively),

Some correlation between responses is obtained between the group with more than 10 years experience (N=149) and the group who have attended some form of advanced training course (N=129). In order of importance, both groups stated that the examination should be performed continuously (78 per cent and 78 per cent respectively), at the start of each shift (54 per cent and 50 per cent) and at regular times during the shift (19 per cent and 21 per cent).

The fact that 100 per cent of responses did not include an examination of the hangingwall at the start of each shift suggests that (a) the question was misunderstood or, (b) that it is not done all the time. There were some regional differences but there appears to be no reason for this finding.

5.7 Discipline

The risk assessment found a lack of discipline to be a significant factor insofar as workers (all groups) regularly failed to carry out instructions to carry out an examination, follow a designed procedure to install support and so forth. Changes that have occurred in the workplace were considered to have contributed to this situation, including protracted disciplinary procedures, and a need was expressed for procedures to be expedited.

The opinion survey found that the "human element" of poor attitude, lack of motivation, complacency, carelessness, laziness and so on to be the major factors in failing to detect and remediate hangingwall hazards (74 per cent). This supports the finding of the risk assessment which is a major concern for two reasons. The most important, perhaps, is the perception created that workers decide what they will or will not do; the second is that they may deliberately not do something designed to safeguard themselves or fellow workers simply because they cannot be bothered.

In the opinion survey, at the conclusion of each interview candidates were given an opportunity to state why they felt examinations were poorly done and identified hazards were not remediated. Twenty-five per cent stated that it was a question of motivation, attitude or carelessness. Twenty per cent gave the same reason for not remedying hazards. Why this should be is beyond the scope of the project although it is suspected that this response is symptomatic of a number of underlying issues. These issues need to be investigated further.

5.8 Summary - Judgement of Need

This section records a wide range of practical issues which affect the quality of the examination. The principal findings are that the majority of workers are able to detect poor hangingwall conditions using their senses and existing equipment. There is a serious concern raised, however, that as many as 25 per cent may be disinclined to either conduct an examination or take the necessary action to correct any identified hazard. Other issues, such as labour shortages, substance abuse, material supplies and the condition of cap lamps (poor illumination), will exacerbate this situation. However, these issues probably mask the underlying problems which require further research.

Table 9 Judgements of need relevant to work practice issues

Order	Description of issue	Judgement of Need	Handled by
1	Equipment and materials required to identify and remediate hazards are not always available, especially correct support units.	Review operation and management of stores supply and distribution system on mines.	Mines
		Consider the possibility of designing new adaptable support elements to simplify logistical requirements.	SIMRAC, DME, manufacturers
2	Labour is not always available to perform examination as often as necessary without compromising production	A culture that safety cannot be compromised under any circumstances should be encouraged	Industry
3	Accumulations of broken rock, especially in gullies, prevent adequate hazard identification and remediation	Review loco and track maintenance procedures and implement improvements to the horizontal transport management system to ensure acceptable boxhole cleaning.	Mines
4	Substance abuse is a problem which results in sub-standard work being carried out	Consider the implementation of systems to prevent workers going underground when incapacitated, and enforce discipline through adequate supervision	Mines
		Consider the possibility of implementing education programmes on drug and alcohol abuse	Mines
5	Cap lamps do not always provide the standard illumination level	Review existing systems for managing cap lamp condition and implement improvements	Mines

6 NEW TECHNIQUES OR METHODS TO DETECT UNSAFE HANGINGWALL

The project investigated the possible use of technology to assist workers to identify unsafe hangingwall, and a literature study identified a number of technologies which have been studied for the coal mining industry. The investigation assumed that any technology is required to meet the following criteria:-

- The sensor must quantitatively react to changes in roof conditions; it must be calibrated in such a manner that only changes in the rock which create a real instability situation are identified and indicated;

- Sensors must be easy to install and inexpensive;

- Sensors are linked via an array to a central control and monitoring unit allowing large areas to be measured from one point;

- The system must be mineworthy.

After an evaluation of a certain identified technologies, a number of additional specifications were proposed:-

- Fracture area and thickness. The system must respond to horizontal fractures greater than 3 m^2 and less than 5 mm thick. (To provide a viable warning system, the sensor must respond to thin cracks formed during the early stages of hangingwall failure.)

- Secondary fracture detection. The system must respond to the presence of a second fracture which lies completely beyond and behind the first, or lower, fracture. (Hangingwall, which contains many fractures one above the other, is considerably weaker than one that is less fractured.) A detector which responds only to the first fracture may indicate a hazard too frequently and eventually be ignored.

- Set up time. A system must be ready for use in 10 minutes from the time a measurement area becomes available.

- Depth of signal penetration. The system must be able to detect a single fracture lying at least 30 cm above the exposed surface of the hangingwall. (Approximately 80 per cent of FOG fatalities are caused by blocks less than 60 cm thick.)

- Physical dimensions. The volume of a prototype system must be less than 60 cm^3 and have a mass of less than 20 kg.

- Permissibility. Any system must be intrinsically safe.

Using these criteria as a basis, eleven possible hazard detection systems were identified. These are presented in Table 10.

Table 10 Potential techniques to detect unsafe hangingwall conditions

Size of the dot represents the potential applicability of each technique to address each criterion.

TECHNIQUE	CRITERIA					
	FRACTURE THICKNESS	SECOND FRACTURE SENSITIVITY	10 MINUTE SET UP	30 CM DEPTH	MAXIMUM DIMENSION	INTRINSICALLY SAFE
1. Tracer gas	●	●	●	●	●	●
2. Microseismic	●	●	●	●	●	●
3. Pulsed radar	●	•	●	•	•	•
4. Extensometer	●	●	•	●	●	●
5. Resistivity	●	●	●	●	●	●
6. Spectral analysis	●		●	•	●	•
7. CW Radar	●		●	•	●	•
8. Ultrasonic	●		•	•	●	•
9. Infrared temperature	●		●	•	●	●
10. Microwave temperature	•		●	•	•	•
11. Swept frequency	●		•	•	•	•

From the above table, a short list has been drawn up of those systems which meet criteria and appear to offer the greatest likelihood of success. These systems are:-

- Material transport techniques: the technique uses a tracer gas which is injected under pressure into a drilled hole in the hangingwall . The flow rate of the gas is used as a measure of the fracture density. Gas diffusion is fracture density and size dependent.

- Borehole survey techniques: this technique measures the resistance of the rock in relation to thickness. As the probe passes a fracture, the electrical resistance increases due to the increase in the electrical path.

- Ground penetrating radar: short pulses of electromagnetic energy are reflected from rock discontinuities; fractures can be measured by analysis of radar grams. A drawback of this system is the need for significant data processing and a high level of expertise.

- Microseismic techniques: a single sensor attached to the hangingwall is used to detect microseismic pulses generated by rock movement. Observations indicate that microseismic pulses increase before the hangingwall fails.

- Passive rock movement measurements: this covers any technique that can detect rock movement following mining operations.

It is probable that a prototype model of one system could be produced in two years and a working model in five years, providing that the concept works and suitable funding levels are made available.

It is stressed that, in addition to meeting technical criteria, it is essential that, to have an impact on the effectiveness of hazard identification and remediation, the technology would address a significant number of the issues identified in this report. While technology would probably address certain of the issues identified, for example lack of illumination or the effect of heat on cognitive ability and concentration, it is considered that development of alternative technologies is a subordinate mechanism through which to improve the effectiveness of hangingwall examination.

7 CONCLUSIONS

There are three principle reasons why falls of ground are not prevented, the procedures are incorrect, the workers are not competent to perform the procedures or the environment prevents workers from carrying out the procedures properly.

This project has three important findings. Firstly, that the majority of workers are able to identify potentially hazardous conditions underground. Secondly, that there are a range of issues that tend to compromise the effectiveness of the examination procedure. For example, poor illumination, work procedures and worker selection criteria. Thirdly, that current technology is unlikely to be able to improve the ability to distinguish between safe and unsafe hangingwall conditions.

However, there is no indication that a lack of resources is the primary reason why we cannot prevent falls of ground accidents. Rather, the problem appears to lie in the far more complex "human" area. This project has identified that considerable confusion exists among workers about who is, and should be, responsible for the examination. This appears to have reduced the level of accountability. The complexity of human issues brings with it concerns about how they can be addressed, without the wholesale commitment of everyone involved. Potentially, technologies exist that might aid hazard detection. However, they will be largely ineffective unless properly used and the information provided, acted upon.

APPENDIX 1. Risk assessment of design and operational aspects of hanging wall risks

Appendix 1 contains the report on the risk assessment conducted as part of the project.

The above table shows the various geological and mining conditions that influence hangingwall condition. It can be used to determine the specific action required by specific levels of operating and supervisory staff when these conditions are encountered.

The team identified a number of risks that require more investigation before exact controls can be defined. These risks are listed in TABLE 2.

TABLE 2

RISK RANK	FURTHER INVESTIGATION ACTIONS
1	Investigate the issues surrounding human resources, specifically those related to labour shortages as a result of absenteeism, illness and accidents
1	Continue investigation of a bonus that promotes both safety and production.
1	Investigate the material supply infrastructure from panel planning through to delivery to identify & rectify problems in order to ensure the availability of the correct materials when the channel width changes.
3	Investigate methods of increasing the air velocity in panels where heat/humidity decreases human efficiency (Deep gold mine problem)
11	Investigate whether LUX levels of cap lamps are adequate for proper Hangingwall Hazard recognition; Consider developing a method to check cap lamps for lux and damage before charging to reduce problems with recurring lamp fade;
11	Investigate the noise frequencies that a supervisor must be able to hear when sounding the hangingwall and to set standards to be used by the mine

Note: As part of GAP 202 an investigation will be conducted to establish the optimum LUX levels required to identify unsafe hangingwall conditions.

The team identified low air velocities, and hence high heat conditions in the workplace, to be an important consideration in the proper monitoring of hangingwall conditions

The team identified several potentially significant risks and situation controls where these are already in place. The recommended controls have been divided into three areas.

Procedural Issues - used in the development of Standard Codes of Practice

Work Order Issues - Recommendations requiring engineering or other changes

Training Method Issues - Relevant once the Standard Code of Practice is completed

The tables below should be used to derive an Action Plan that will lead to the definition of a Safe System of Work for the monitoring and control of hangingwall conditions

High risks are ranked between 1 and 6; moderate risk between 7 - 15 and low risk between 16 - 25. The mechanism of ranking is described in the report.

Appendix A1.3

The recommendations for the Procedural Issues are listed in TABLE 3

TABLE 3

RISK RANK	PROCEDURAL ISSUES TO BE IN STANDARD CODE OF PRACTICE
1	Select supervisors considering their experience, skills, safety history as criteria. Train all supervisors in motivation methods and initiative training. Ensure all supervisors understand their responsibilities and not to wait for instructions; Monitor supervisor behaviour ie "not waiting for instructions" & provide feedback to supervisors
2	The purchasing system should be reviewed to ensure that correct support materials are specific to cater for a variety of stoping widths and geological conditions and minimum stock levels for materials are maintained.
3	Review the Operator /Team Leader training system to optimise selection, standards, training content/method, competency testing and monitoring in order reduce human error.
3	Review the guidelines and if necessary introduce procedures for supervisors to test workers that may be impaired as a result of substance abuse or actions be taken if the worker tests as impaired
3	Review the loco/track maintenance system to ensure minimum delays in cleaning gullies (specifically the number of workers available to maintain the tracks); Check Stope layouts with respect to cleaning of sidings.
4	Ensure that any new Standard that affects hangingwall conditions is developed with the participation of all parties concerned
4	Monthly production planning meeting should include minutes & action items re: HW risk control so they can be followed up; Mine layout should include notes on the HW and this plan should be communicated to MO's over the mining period
4	In the exploration phase of planning, it may be desirable to do a cost benefit analysis on increase drilling versus other geotechnical methods to identify the structure/conditions that causes hangingwall condition problems.
7	Include experienced mine overseer on mine planning team for mine layouts, projects, sub-shafts, etc. specifically responsible for hangingwall conditions

The Work Order Issues are shown in TABLE 4

TABLE 4

RISK RANK	WORK ORDER ISSUES
3	Ensure that supervisors are trained to install water traps and to check water-tube maintenance
13	Consider changing Rock Stud nut to limit damage caused by scrapers.

The Training Methods Issues are given in TABLE 5.

	TABLE 5
RISK RANK	TRAINING METHODS ISSUES
1	Reinforce the need for supervisors to follow-up on instructions Train supervisors to give proper job instructions and give them in a clear, easy to remember manner; Train supervisors in methods to help operators be aware of high safety risk areas and practical information on how to handle potential hazards/dangers.
1	Train operators that they are responsible to follow proper job instruction/procedure.
1	Operator must be made accountable; Instruct supervisors re discipline policy use to deal with "deviant" human error on the face.
2	Do condition monitoring and HW related training U/G in real conditions that represents all expected conditions.
3	Use illustration/cards to model, train/communicate hazards; Ensure that the learning of fanakalo is important for all levels of supervision: Support English training.
4	Select supervisors for language skills and /or train supervisors so they can communicate with the relevant personnel.
4	All levels up to Mine Overseer to be trained in Hangingwall risks and condition monitoring.
5	Standards training in regard to drilling. Noting that advance greater than 1.2m may cause damage to hangingwall.
9	Training with regard to Water Jet Cleaning. Noting the importance of keeping water away from brows.

It remains for mine management to review the above recommendations and develop an Action Plan to make the changes that are required to manage the risk to a more acceptable level. It is suggested that a format such as the following be used;

Recommendation	Action	Accountability	Due Date

2. Introduction

Falls of ground have been a major cause of injuries and fatalities in the Evander District [redacted], as well as at other deep gold mines in South Africa. As part of a SIMRAC funded project focusing on the identification of underlying factors which prohibit effective examination of the hangingwall, it was proposed that a Risk Assessment might be done on the "hangingwall risks" at [redacted] Mine.

Formal Risk Assessment is being introduced to the South Africa, partly because of the recent Leon Report on Occupational Health and Safety in the South African Mining Industry, which suggested that historical high loss areas, such as falls of ground, should be addressed by this methodology.

The method being introduced by MineRisk Africa involves the classic approach to assessing risks, as outlined in the numerous world wide Standards and Guidelines on the topic.

- Identify the hazard (events with the potential for harm)
- Assess the risk by considering the likelihood and consequence of the potential events
- Determine acceptability of the risk
- Identify priority actions for the control of unacceptable risks

When examining the hangingwall risk, that manifests itself in a fall of ground, it would be necessary to define the system which is either currently used to manage the risk, or the system that is intended to manage the risk in future.

As part of the Risk Assessment at [redacted], a new method of Condition Monitoring was developed for use by all personnel from Mine Overseer to Operator. Development of this new method required the facilitation of a multi-step process to derive an approach that could help personnel in systematically looking for the most reliable indicators of unacceptable hangingwall risk. The method was also developed to include clear action criteria and specific identified actions for each condition.

Once this new method was developed, it was included in the entire hangingwall risk system from design to action.

It is intended that the results of the Risk Assessment will be forwarded to the General Manager of [redacted] Mine for his consideration. Once an Action Plan has been defined for the recommendations he wishes to implement, a Hangingwall Risk Management Plan will be drafted.

A Risk Management Plan is a document which defines the risk, its' specific location in the mine and, most importantly, the critical personnel, method and equipment controls to ensure the risk is managed to an acceptable level. A Risk Management Plan should also include mechanisms for monitoring compliance, watching for changes at the mine which might change the risk and reduce plan effectiveness, as well as a method for auditing the entire plan on a regular basis.

This approach to controlling priority hazards in mining, which are perhaps considered to present catastrophic risks, has proven effective to focus mine attention on these priorities, ultimately reducing the potential losses in that area.

A meeting was held on 27th July 1995 with the Acting General Manager of [redacted] Mine, Mr. Alan Dods and the mine rock mechanics engineer, Mr. Erkki Makinen. The possibility of using a Risk Assessment technique to examine the hangingwall risk was discussed. As a result of the discussion, a project was outlined and executed.

3. Objective:

The objective of the project was to apply Risk Assessment and Risk Management technology to review relevant mining design and operational systems which would result in a reduction of hangingwall risks. In addition, the review will produce a method to assist relevant personnel in monitoring conditions to identify and control hangingwall risks, as well as a document outlining the priority equipment, methods and competencies required to minimize hangingwall risks at the mine (of which the new condition monitoring method would be a part).

4. Method

A multi-step process was used to facilitate a team of [redacted] personnel through the development of a useful condition monitoring method based on good Risk Management principles. Once that was completed, a Risk Assessment method was used to systematically review the existing design, planning, communication and operational systems that affect the hangingwall risk.

The team involved in the project was;

Mr. Collie Russouw,	Production Manager
Mr. Erkki Makinen,	Regional Rock Engineering Consultant
Mr. Hannes Cillier,	Mine Overseer
Mr. Hennie van Aswegen,	Training Manager
Mr. Johan van Vuuren,	Safety Co-ordinator
Mr. Daniel,	Team Leader
Mr. Andrew Peake,	CSIR - Miningtek
Dr. Bernard Madden,	CSIR Minigtek

The team was facilitated through the project by Mr. Jim Joy, MineRisk Australia and the information was gathered into a computer by Mr. Nick MacNulty of MineRisk Africa, part of CSIR - Miningtek.

Specifically, the following points outline the method;

1) Introductions of all team members.

2) Brief overview of Risk Assessment and Risk Management information by MineRisk.

3) Definition of the "hangingwall risk" by the team.

4) Identification of the geological and mining factors that affect and/or contribute to the hangingwall risk

5) Prioritisation of the geological and mining factors based on the likelihood that personnel would be able to see them and the degree to which the factors were accurately indicative of a pending fall of ground

6) Listing of the specific, most effective conditions that should be monitored and the personnel in the mine that should be monitoring the condition

7) Development of a matrix model of specific geological and mining conditions and recognition by the relevant mining personnel.

8) Definition of a [redacted] Hangingwall Condition Monitoring Method.

9) Identification of required actions for addressing unacceptable geological or mining conditions that are identified using the new Conditions Monitoring Method.

10) Drafting of a systems model (flow chart) outlining the system of designing, planning, resourcing, communicating and operating, including the new Condition Monitoring Method.

11) Execution of the Risk Assessment method to review the model identifying potential incidents or accidents, ranking the risk for each.

The Risk Assessment tables in the Results Section illustrate the step-by-step process involved on the Risk Assessment.

The specific risk scoring method involved the following approach to ranking risk. The team picked the letter (A to E) best representing their opinion of the likelihood that a loss event might occur. Secondly, the team selected the maximum reasonable consequences, should the event occur. The highest rank number (i.e. 1 = first) was selected from the three potential loss areas of people, assets and production.

TABLE 6

Probability or Likelihood of the event	Maximum Reasonable Consequences should the event occur			
		People (Safety)	Assets (Damage)	Production (Delay)
A Common, approx. 1/day	1	multiple fatality	>R1 mill. damage	> 1 day, multiple panel
B Occurs often, approx. 1/week	2	a fatality	R200 K - 1 mill.	1 day, 1 panel
C Occasional, approx. 1/ month	3	a serious LTI	R50 K - R200 K	1 shift, 1 panel
D Seldom, approx. 1/year	4	an average LTI	R10 K - R50 K	hours, 1 panel
E Very seldom, approx. 1/5 years	5	minor LTI or less	< R10 K	< 1 hour

Once the team selected one letter for likelihood and one number for consequences, the two were combined to establish a risk rank for each loss scenario.

TABLE 7 shows the risk levels based on the probability of an event occurring and the probable consequences.

TABLE 7					
	Prob. - A	Prob. - B	Prob. - C	Prob. - D	Prob. - E
Cons. - 1	1	2	4	7	11
Cons. - 2	3	5	8	12	16
Cons. - 3	6	9	13	17	20
Cons. - 4	10	14	18	21	23
Cons. - 5	15	19	22	24	25

12) Sorting of the list of potential incidents to identify priorities to help the team focus on identifying existing controls and new potential controls to reduce the risks.

13) Discussion of the controls related to one area of priority risk - the supervisors adherence to methods of monitoring hangingwall .

Following the acceptance of the draft Risk Assessment Report, it is suggested that the Risk Management Exercise is completed as follows;

1) Drafting and submission of the Risk Assessment Report document for the client, Mr. Dods, by MineRisk, Africa

2) Action Planning by mine management

3) Drafting of Hangingwall Risk Management Plan using information from Risk Assessment and Action Plan, by MineRisk, Africa

4) Submission of the draft Hangingwall Risk Management Plan to the client

5) Finalisation of the Hangingwall Risk Management Plan by MineRisk Africa after feedback from [redacted]

Appendix A1.10

Results

4.1 Definition of the hangingwall risk

The hangingwall risk involves a fall of ground, small or large/major sections caused by geological features and mining activities, natural and man made

4.2 Potential conditions that can be monitored.

The team concluded that the following geological and mining factors have a significant influence on hangingwall conditions, as shown in TABLE 8.

	TABLE 8
FACTORS AFFECTING HANGINWALL CONDITIONS	
Geological	**Mining**
Faults	Stope layouts-if layout does not consider geology
Dykes	Mining layouts
Slips	Drill & blast not correct for geology
Rock type	Not to standard
Feather wedging	Configuration - increase in stress
Cross bedding	- leads and lags
Lack of adhesion	- fracture increase
Presence of different rock type	Support - not correct for geology
Bedding planes	Lack of support - not standard
Presence of water	Cleaning - scraper hit / impact hangingwall
Thickness of strata	
Depth	
Different channel width & dip	

4.3 Prioritisation of the factors affecting hangingwall conditions

The criteria to identify the various geological and mining factors and relevant personnel table were drawn up. The criteria were then ranked in terms of reliability based upon the likelihood and accuracy of being identified, as shown in TABLES 9 and 10.

GEOLOGICAL FACTORS — TABLE 9

Factor	Likely to see	Accuracy	Reliability	Criteria & Relevant Personnel
Faults	A	1	1*	Brow/plane MO - Op
Dykes	A	1	1*	colour change, drilling MO - Op
Slips (note interaction)	C	2 (1)	9 (6*)	inconsist plane, fractured MO -Op
Cross bedding	D	3	18	
Rock type i.e. shale etc.	B	2	5*	different colour, structure MO - TL
Water	A	1	1*	Wet MO - Op
Feather wedging	D	2	14	MO - Op
Strata thickness changes (if fallen out)	E	4	24	
Change in reef thickness and dip	A	1	1*	Working width increase <1.2, 1.21-1.6, 1.61-2.4, >2.4 MO-T/L
Previous Falls of Ground	A	2	2*	Parting, can't bar Sound hollow MO-T/L

MINING FACTORS				TABLE 10
Factor	**Likely to see**	**Accuracy**	**Reliability**	**Criteria & Relevant Personnel**
Layout Plan U/G Pre- work plan ,	A	1	1*	Hangingwall related characteristics and issues (multiple) RM - MO
Drill & Blast	A	1	1*	Sockets in the hanging, deterioration , incorrect alignment of holes, over charging of hole, incorrect burden, incorrect hole pattern MO - TL
Support	A	1	1*	Blasted out support, not to standard, support missing MO - TL
Face Shape U/G	A	1	1*	Corners, lagging, no sidings, poor/difficult cleaning SB - TL
Cleaning	A	1	1*	(indicative of above problems only)
Layout Control U/G	A	5	25	faces leading - out of sequence MO - SB

Ratings - Likely to see; A-100% B-75 C-50% D-25% E-0%
- Accuracy; 1-100%, 2-75%, 3-50%, 4-25%, 5-0%
* = critical areas

Table 11 shows the personnel responsible for monitoring a specific condition

PERSONNEL RESPONSIBLE FOR CONDITION MONITORING							TABLE 11
	Rock / Geo.	Prod Manager	Mine Overseer	Shift Boss	Miner	Team Leader	Operator
Geology - Fault			↑	↑	↑	↑	↑
Dyke			↕	↕	↕	↕	↕
slip			↕	↕	↕	↕	↕
water			↕	↕	↕	↕	↕
Previous fall			↕	↕	↕	↕	↓
Rock Type			↕	↕	↕	↕	
Channel Width			↓	↓	↓	↓	
Mining - Layout	↕	↕	↑				
Layout execution			↕	↑			
Face shape			↕	↕	↑	↑	
Drill blast			↕	↕	↕	↕	
Support			↓	↓	↓	↓	

4.5 Hangingwall Condition Monitoring Method

TABLE 12 shows the Condition Monitoring Process for different job categories.

TABLE 12		
Process Steps	**Operators to Team Leaders (Face Personnel)**	**Miner to Mine Overseers (Supervisors)**
LOOK	Before starting any task - Pause and Look and Sound the conditions in a new location	Every time you visit a working place- Pause and Look and Sound the conditions in a new location
COMPARE	Compare with the relevant criteria	Compare with the relevant criteria
DECIDE	If what you see exceeds criteria then Act as per defined actions	If what you see exceeds criteria then Act as per defined actions
ACT	Take the required Actions	Take the required Actions

4.6 A list of specific required actions for identified unacceptable hangingwall conditions related to geology is given in TABLE 13

TABLE 13	
Identified Unacceptable Geological Condition	**Action**
Visible brow of size (any)	Bar Down and Support
Inconsistent planes (any)	Mark It and Support
Different rock colour or type (any)	Sound it, Support and Report
Change of rock colour i.e. while drilling (any)	Report
Visible Cracks, open fractures(any)	Sound it, Bar and Support
Different composition of rock (any)	Sound It, Bar and Report
Water (any)	Sound it, Bar and Report
Visible parting (any)	Bar down and Support
Fall of Ground	Bar, Sound it, support, Report
Change in Width	Measure, Change Support category, Report

Appendix A1.14

The required actions where unacceptable geological conditions were identified are shown in TABLE 15.

TABLE 15

ACTION	CONDITION: If FOG	Visible Open Fracture	Diff Rock Colour	Diff Rock Comp	Water	Visible Brow	Visible Parting	Incon Plane	Change in drill water colour	Change in Width
Bar Down	X	X	Y	X	X	X	X			
Sound	X	X	X	X	X	X	X			
Support	X	X	X	X	X	X	X	X		
Report	X		X	X	X			X	X	X
Mark								X		
Measure										
Change to New Std										X

4.7 List of specific required actions for identified unacceptable hangingwall conditions related to mining operations is shown in TABLE 16.

TABLE 16

Identified Unacceptable Mining Condition	Action
Drill & Blast Conditions:	
Sockets	Sound, Bar down, Correct the method
Deterioration	Sound, Bar down, Correct the method
Drilling Direction	Correct the method
Pattern	Correct the method
Overcharge	Correct the method
Burden	Correct the method
Support: Blasted out	Sound, Bar down, Fix support, Report
Support: Not to Std	Sound, Bar down, Fix support, Report
Face Shape, Alignment:	
Corners	Talk to miner, Fix, Correct the method
Lagging	Talk to miner, Fix, Correct the method
not to std	Talk to miner, Fix, Correct the method
deterioration	Sound, Bar down , Correct the methods
poor cleaning	Talk to miner, Fix, Correct the method
Sidings	Talk to miner, Fix, Correct the method
Face Shape, Alignment:	
Leading	Fix, Correct the method, Report
Faces out of Sequence	Fix, Correct the method, Report
Where mining where shouldn't be taking place	Fix, Correct the method, Report

Table 17 shows the required action by unacceptable mining condition

						TABLE 17
	MINING CONDITIONS					
	Drill & Blast Sockets Deterioration	Drill & Blast Drill Dir. Pattern Overcharge Burden	Support Blasted Not to Std	Alignment Deterioration	Alignment Corners Poor Cleaning Not to Std Sidings	Layout Sequence Leading Not to Std
Bar Down	X		X	X		
Sound	X		X	X		
Support	X		X	X		
Talk to miner Before					X	
Fix It					X	X
Correct Method	X	X	X	X	X	X
Report			X			X

4.8 Flow Chart of the Hangingwall Management System

Figure 1 shows the flow chart of the Hangingwall Management System. The following is additional information used to develop the flow chart:

1. **Exploration** -

    Drilling, logging interpretation
    Seismic Investigations
    Radio Magnetics
    Historic regional
    Regional Structural Information

2. **Concept Mine Considered**

    Interpretation and Evaluate of data

3. **Develop Mine Plan**

    Decide mining method
    Set layouts
    Set standards

4. **Develop Standards for Operating Method**

5. **Acquire Equipment**

    Drills
    Explosives
    Mobile Equip
    Props
    Support material

6. Instruct People re Operations

Prod Manager to Mine Overseer (day before)
Mine Overseer to Shift Boss (At start of shift)
Shift Boss to Miner or Team Leader (during shift
Miner to Team Leader (during shift and U/G)
Team Leader (U/G)

4.9 Risk Assessment Sheets

The Risk Assessment sheets as developed by the team are included in Appendix I. The sheets have been organised based on type of issue (equipment, environment, method, personnel, system).

APPENDIX 2 Opinion survey - summary of findings

Sample Page

Total Sample	193
Experience Groupings;	
<1 Year	5
1-2 Years	2
2-5 Years	3
5-10 Years	33
>10 Years	149
Job Level Groupings;	
Official	14
Blasting Ticket Holder	23
Supervisor	95
Worker	61
Mine Groupings;	
Mine 1	35
Mine 2	38
Mine 3	35
Mine 4	42
Mine 3	43
Training level Groupings;	
Advanced Supervisors Course	129
Refresher Course	57
Beginner's Course	6

Executive Summary.

Equipment and resources needed for hazard identification and remediation;

The equipment and resources needed for hazard identification and remediation were usually available and in good condition. Most of the complaints about lack of equipment came from Mine 1 people, but only 3-6% of interviewees complained about this.

Pinch bars and four pound hammers were the items of equipment needed most often for hazard identification. Timber props, pinch bars, four pound hammers and packs were mentioned most often for hazard remediation.

Usage of equipment varied to some extent with training level and experience. Inexperienced people needed more safety equipment than experienced ones. Equipment used for remediation also varied by Mine and job category. Mechanical props were mentioned most often by officials; four pound hammers were more important to blasting ticket holders and supervisors than to other groups; and packs to workers and supervisors. This seems to indicate different approaches to remediation by the different groups.

Condition of equipment;

20% of the Mine 1 people we interviewed said that the pinch bars had missing hand guards and 14% that they were not sharp. Officials also complained about pinch bar condition. 3% of Mine 1 interviewees also said that they had problems with the condition of their cap lamps. Reasons given for this poor condition concerned laziness and the attitude of people towards their work. Otherwise, equipment was mostly in good condition.

From the above results it is apparent that shortage of materials was not a major factor in preventing hazard identification and remediation.

Environmental Conditions;

High noise levels were a problem to half of the people interviewed. The groups which were most affected were less experienced people, officials and Mine 1 and 4 people. Noise was a problem because people could not hear the hanging talking, hear soundings, or warnings and it was distracting.

High temperatures caused problems for 59% of the people interviewed because it induced fatigue, poor concentration and lack of strength, and caused irritability and impatience. There was some variation in response to high temperatures across categories. Slightly fewer people in lower job categories said it caused problems. 80% of Mine 3 people saw it as a problem.

Poor visibility and illumination caused problems for hazard identification and remediation because people couldn't see well under those conditions.

Confined workings caused problems for only 30% of the people we interviewed. The people most affected by them were those from Mine 3, or people with little training or experience, and officials. The cramped position they caused was the source of the problems they caused.

Steep dips were also only a problem to 35% of interviewees mainly because of poor footing, rolling rocks and difficulty in installing support. There was some variation across categories of people.

In general, these environmental conditions caused problems of hazard identification and remediation for half or less than half of the people interviewed.

Procedures;

The majority of people we interviewed said that before doing a hanging wall examination one should water down and inspect for misfires. Response varied across job categories, presumably in accordance with differing responsibilities. There was also variation across mines. More experienced people mentioned more activities.

76% of interviewees said that hanging wall examinations should be done continuously, and 56% that they should be done at the beginning of the shift. They said that this was what usually happened. They said that if it was not done it was due to negligence, poor attitude, or less frequently, lack of training or production pressure. There was a varied response across job categories. 86% of officials said that examinations should be continuous but 14% of them said they were not. Only 29% said examinations should be done at the start of each shift but 7% said that they were not done then. 67% of workers said they should be done at the beginning of the shift and that they were done then. There was considerable variation in the response of people from different mines to this question. Mine 3 and 5 people said mostly that examinations should be done continually, Mine 2 and 4 people that regular examinations should be done and Mine 1 people that they should be done at the start of the shift.

Most people we interviewed (79%) said that everyone underground should be responsible for examining the hanging. Only 3% said they were not, mostly because of laziness or because they felt it was someone else's responsibility. Team leaders were second favourites for carrying this responsibility. Responses varied considerably across categories and I will not list them again here. People with little training or experience preferred someone in authority to take responsibility. 9% of people with 5-10 year's experience; 9% of blasting ticket holders; 14% of Mine 1 people and 21% of officials said that 'everyone underground' did not take responsibility for examinations, although many of them thought that everyone should. Mine 3 and 5 people were inclined to hold everyone responsible and said that they did take this responsibility. On other mines, various people were listed as candidates for this responsibility.

Most of the people we interviewed knew and understood and applied the code of practice/standard. exceptions to this were 10% of workers, 17% of Beginner's course people and some of the less experienced people. 14% of officials said that it was only applied sometimes.

Visual inspection, sounding and barring down were mentioned most often as techniques which should and were being used for hanging wall inspection. 7% of officials said that soundings were not done. Different techniques were important to people from different mines, but the basic techniques came up consistently.

The majority of the people we interviewed identified photographs of hazards as such. Again there was variation across various categories of people. Photos of stable situations were also often identified as hazards, but generally not as frequently as the other photos. Few beginner's course people said that photo 4 depicted a hazard.

Installing support and barring down were mentioned very frequently as remediating procedures for hanging wall hazards. Fencing off was mentioned much less frequently. Officials mentioned fencing off reasonably often. Reporting the hazard was brought up by less well trained and less experienced people.

For fault or slip hazards installing support was the only measure mentioned by large percentages of people. Barring down was mentioned much less frequently. 8% of all interviewees did not know what a fault or a slip hazard was. These people were mainly supervisors and workers. People with little experience or training mentioned reporting the hazard or fencing it off often. Responses were different on different mines.

Over 70% of interviewees said that when a hazard could not be remedied it should be fenced off or reported to a miner or team leader. 23% suggested using an alternative measure. Most people said that what they suggested was what actually happened. Officials and miners mentioned blasting at the end of the shift. Responses from different mines varied.

Opinions as to who should be responsible for deciding on a remedial measure varied tremendously between groups and the summary for this question is well worth reading for more detailed information.. The most frequently mentioned were the Miner, the Team Leader, and everyone underground; followed by the Shift Boss and the Mine Overseer. Relatively high percentages of interviewees said that the people who they felt should take responsibility for deciding on remedial measures were not actually responsible. They said that this was because the mine overseer or shift boss were often not present, the team leader or miner lacked the relevant knowledge and 'everyone' did not take responsibility.
A majority of people interviewed said that the examination should not and did not stop. Some said it should only stop when all hazards had been identified and remediated. People with less than 5 year's experience also said it should stop on the instruction of the miner or team leader. There was otherwise not much variation between job categories. The main differences were between mines. On mine 5, 4 and 3 all or many people said examination should not and did not stop. Responses were broader on the other two mines. 11% of Mine 1 people said that the examination stopped after the worst situations had been made safe.

71% of the people we interviewed said that nobody should be responsible for stopping the examination. People with less experience or training added the miner and team leader to this list, as did Mine 1 and 2 people. Mine 2 people also mentioned the shift boss. Mine 3, 4 and 5 people, who also said that the examination should not be stopped, said that nobody should be responsible for stopping it.

The questions on responsibility have yielded much useful information which could be very useful in working out how to remediate attitude problems. They are well worth looking at in detail, bearing in mind the conditions on each mine and the circumstances of people in the various job categories.

Main problems with examinations;
If one takes a step back from the reasons which interviewees gave for failure to identify and recognise all hazards, it becomes apparent that the 'Human element' of poor attitude, lack of motivation, complacency and carelessness, laziness and so on was the major factor here. This theme was brought up 143 times. Lack of training and knowledge was raised 46 times; production pressure 36 times; negligence at work, poor working standards, shortcuts and so on; 33 times. 33 people said that hazards were always recognised; 31 that failure to recognise hazards was due to shortage of material or equipment (or its poor condition); and 22 that environmental conditions made it difficult or impossible to identify hazards.

A similar situation prevailed as far as reasons for failure to remediate hazards was concerned. The reasons which people gave here were very similar to those they gave above.

F. Main problems:

31. Major Problems With Examination;

Summary.

If one takes a step back from the reasons which interviewees gave for failure to identify and recognise all hazards, it becomes apparent that the 'Human element' of poor attitude, lack of motivation, complacency and carelessness, laziness and so on was the major factor here. This theme was brought up 143 times. Lack of training and knowledge was raised 46 times; production pressure 36 times; negligence at work, poor working standards, shortcuts and so on; 33 times. 33 people said that hazards were always recognised; 31 that failure to recognise hazards was due to shortage of material or equipment (or its poor condition); and 22 that environmental conditions made it difficult or impossible to identify hazards.

A similar situation prevailed as far as reasons for failure to remediate hazards was concerned. The reasons which people gave here were very similar to those they gave above.

31. Major Problems With Examination;

Major problems causing the hanging wall examination to be ineffective as perceived by mine employees (N=193).

a. Failure to identify and recognise all hazards;

Problems;	*No of times raised;*
Lack of motivation/poor attitude/carelessness	49
Lack of training/knowledge	43
Production pressure	36
This never happens	33
Lack of equipment/materials	28
No co-operation/teamwork	22
Laziness	18
Complacency	17
Lack of concentration	14
Taking chances - short cuts/hurrying	13
Not following procedures/poor working standards	13
Poor supervision	10
Inadequate cleaning	6
Mine tremor	5
Do not know	4
Environmental conditions	4
Staff shortage	3
Not doing the examination properly	3
Rockburst	3
Fatigue and concentration problems from heat	3
Human error	3
Poor eye sight	3
Lack of experience	3
Hurrying to finish the job	3
Nobody under the team leader accepts any responsibility	2
Ground closure	2
Poor communication	2
Fatalism	2
Everyone assumes someone else has done the job	1
Stoping width	1
Lack of research into new methods and equipment	1
Need better support design	1
Acclimatisation to working areas	1
Rock cracked but not talking	1
Faulty equipment	1
Lack of compliments	1
No discipline	1
Disregard of safety training	1
No follow-up on early shift	1
Physical condition of examiner	1

Ventilation causes dust	1

Verbatim Comments;

"Rock not talking to me but having cracked."

"Due to an attitude of complacency. The environment induces a could not care less attitude. There is much stress and supervision is poor. Training is inadequate."

"....There is a lack of understanding and comprehension of consequence."

"When the supervisor fails to give safety talks to remind everybody of danger. Also, personnel problems may lead to lack of motivation."

"Poor attitude - they could not care less. There is no commitment to safety."

"Poor attitude, high temperature, lack of material and people's lack of awareness of danger and lack of safety awareness."

"Complacency is a problem and barring is a difficult job. Everybody assumes someone else has done the job. Supervision is a problem."

"Neglecting to do a complete job; carelessness, shortage of material, and lack of commitment."

"Lack of awareness of danger; disregard of safety training and a 'devil may care' attitude."

"There is no follow-up on the early shift. There is no discipline. Safety talks are irregular."

"Conflict between team leaders."

"Shortage of materials and not seeing eye to eye with colleagues."

"Shift Boss not concentrating."

"Different views of Miner and Team Leader."

"No planned stoppage for examination."

"Early examination done but no follow - up."

"When half jobs are done."

"Not barring down properly."

"Fatalism."

b. Failure to remediate identified hazards;

Problems;	*No of times raised;*
Lack of training/knowledge	46
Lack of motivation/poor attitude/carelessness	38
Production pressure	36
This never happens	33
Lack of equipment/material	29
No co-operation/teamwork	19
Poor work performance/lack of pride in your work	18
Complacency	11
Poor supervision	10
Laziness	7
Negligence/carelessness	6
Daydreaming/lack of concentration	6
Mine tremors	5
Hurrying to finish	5
Taking chances - short cuts	4
Hurrying to finish the job	4
Inadequate cleaning	4
Staff shortage	3
Rockburst	3
Don't know	3
Fatigue and concentration problems from heat	3
Poor eye sight	3
Human failure	3
Lack of experience	3
Ground closure	2
Fatalism	2
Lack of discipline	2
Poor communication	2
Nobody under the team leader accepts any responsibility	1
Stress	1
Lack of compliments	1
Lack of research into new methods and equipment	1
Need better support design	1
Acclimatisation to working areas	1
No planned stoppage for examination	1
Not following up on early shift	1
Sometimes have to work though barring has failed	1
Proper stores management	1
When area not barricaded off	1
Faulty equipment	1
Physical condition of the examiner	1
Stoping width	1

Verbatim Comments;

"With the exception of mine tremors, most hazards are remediated."

"This never happens. If we cannot remediate we barricade completely."

"Mine tremors are our major problem in hazard remediation."

"Staff shortages; equipment shortages; and no co-operation between staff and miner."

"Lacking in discipline; lacking in knowledge and training; and are unaware of the consequences."

"'Devil may care' attitude."

"A poor attitude - a preoccupied mind."

"Lack of concentration on the job."

"Misunderstanding among the team."

"Supervisor does not follow up on instructions given."

"There is a lack of training and unwillingness in the training."

"Leaving it for later - one may forget to do it."

"Not working to rock mechanic specifications; poor installation of support; failure to clean footwall; packs not pre-stressed."

"Fear of hazardous conditions and laziness."

One man felt safe whenever he saw support, no matter what its condition was.

Sample Page

Total Sample	193
Experience Groupings;	
<1 Year	5
1-2 Years	2
2-5 Years	3
5-10 Years	33
>10 Years	149
Job Level Groupings;	
Official	14
Blasting Ticket Holder	23
Supervisor	95
Worker	61
Mine Groupings;	
Mine 1	35
Mine 2	38
Mine 3	35
Mine 4	42
Mine 3	43
Training level Groupings;	
Advanced Supervisors Course	129
Refresher Course	57
Beginner's Course	6