SAFETY IN MINES RESEARCH ADVISORY COMMITTEE

SIMRAC

Final Project Report

Title:	IDENTIFICATION OF CAUSES OF UNSAFE ACTS OR NEGLECT RESULTING IN ROOF OR SIDEWALL ACCIDENTS
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PREFACE

This report contains certain recommendations which require extensive Rock Engineering investigations to satisfactorily reach the conclusions that have been made. It is the opinion of the Safety in Mines Collieries Committee that the findings pertaining to roof support methods were not adequately researched by a suitably qualified Rock Engineer and should, therefore, not be interpreted as authoritative, but rather conveys the perceptions of the authors.

EXECUTIVE SUMMARY

Despite all the attempts made to create a safe work environment for employees working in coal mines during the past nine years an average of 25 miners died every year, and 229 were injured. In 45% of the deaths and in 24% of the reported injuries the cause was roof and sidewall accidents. The primary objective of this project was to identify the causes of unsafe acts or neglect resulting in roof and sidewall accidents in coal mines.

In an attempt to identify these causes the following aspects were investigated:

- The reasons for causes of unsafe acts or neglect as documented in the literature
- The perceptions of South African employees in this regard
- How South African employees are trained to behave in a safe manner
- How safety is communicated in South African mines
- The standards and regulations to ensure a safe working environment.

The following research processes were used to gather information from the available sources:

- A literature survey to identify international trends
- A questionnaire survey to determine the perceptions of employees in terms of the reasons for unsafe behaviour
- Interviews with key role players in coal mines and the coal-mining industry
- Observations during mine visits.

The project team came to the conclusion that there were a few key reasons why employees go under unsafe roofs and ignored unsupported sidewalls.

- The rewards available focus exclusively on increased output not on sustaining good safety performance
- The infrequency of serious consequences arising from unsafe behaviour builds complacency amongst employees on all levels
- Poor communication amongst employees reduces the impact of hazard identification and hinders corrections to unsafe behaviour
- Current safety training does not promote safe practices. Much current safety training is too general and/or does not reflect current mining practices.
- Ambiguity of the roles of safety officers and safety representatives causes uncertainty of accountabilities.
- The process of managing is perceived as primarily a process of minimising of costs rather than engineering safe working environments
- Techniques for hazard recognition are inadequate - too many declared safe areas prove not to be safe
- The focus on recording consequence rather than accidents limits analysis of safety records.

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- Techniques for hazard recognition are inadequate - too many declared safe areas prove not to be safe
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The range of solutions, specified below amount to a shift in the culture of management in mines. No significant improvement in safety can be expected without observable changes as follows:

- **MINE REWARD SYSTEMS FOCUS ON PRODUCTION, NOT SAFETY**

  Attempts should be made at industry level to ensure a balance between production and safety. Stakeholders in the mines should form a forum to develop ways and means that would ensure a profitable enterprise where employees could feel safe.

- **EMPLOYEE COMPLACENCY IS NOT COUNTERACTED**

  Employees should be made aware of the dangers surrounding them without scaring them so much that they can no longer perform excellently. Employees should be told of accidents in other mines and why these accidents occurred. However, this would only be possible if a proper, centralised recording system was available.

- **NO COMMON LANGUAGE**

  As long as employees do not understand instructions, they will not be able to heed warnings and the mistrust between groups will remain.

  The mining industry should seriously consider the feasibility of reinstating, developing and refining an operational language similar to Fanagalo. The shortcomings of Fanagalo should be investigated and excluded from this operational language. It should be made compulsory for every employee, from the mine manager to the lowest operational employee, to attain a certain level of competence in this language.

- **INEFFECTIVE COMMUNICATION ON SAFETY AND HAZARDS**

  The communication network should be based on the structure of the mine. Key communicators and communication skills should be identified, in relation to the roles and responsibilities of the different role players in the safety structure. These key communicators, who should be supervisors, safety officers and safety representatives, should be authorised to take steps, within specified limits, against employees who behave unsafely. Regular forum meetings should be held to discuss problems and opportunities. These key communicators should view themselves as a team with the objective to reduce accidents, and in particular roof and sidewall accidents.

- **OUTDATED TRAINING METHODS AND MATERIALS**

  The information age and the emancipation of employees had a considerable impact on training requirements. New training material should be developed in a participative manner. Representatives of labour, the engineers, management and training professionals should be involved. All training materials should be related to the machinery and skills that are currently used.

  Creative ways have to be identified to ensure continuous learning (see 2.1.4.3 for more details).

- **INEFFECTIVE UNDERGROUND SAFETY STRUCTURE**

  The relationship between the safety representative and the safety officer has to be clarified. The roles and responsibilities of the two positions should be documented and communicated to all the employees. The employees who are selected to fill these positions should receive training in the competencies that would be required to ensure safety.

- **THE ROLE OF SAFETY REPRESENTATIVES**

  The current job description of the safety representative serves no purpose at all. Nothing in respect of safety will change if the post is done away with.

  The NPI recommends the following in this regard:

  - Give the position autonomous status.
  - Delegate more authority to the position, even to the extent of giving the safety representative a veto right to stop activities for safety reasons if deemed necessary.
  - Only appoint well-trained, experienced candidates with an appropriate educational background in this position.
  - A candidate who is selected by the team should first pass scrutiny, based on the above and other prerequisites, before he is appointed and trained.
  - Only candidates with a proven track record of reliability, honesty and enthusiasm, with the right temperament and personality, should be appointed to the position of safety representative.

- **THE SUPPORT PHILOSOPHY DOES NOT CREATE A SAFE WORKING ENVIRONMENT**

  - **Systematic support or not**

    At the moment the law allows the COP advisory committee to determine the general support philosophy at each mine. The committee decides whether the mine requires 100% systematic support, systematic support only where needed, or non-systematic support, with the option to move to minimum support and/or systematic support.

    As evidence of a change in the mine management culture the NPI recommends that serious consideration is given to the current practice of systematic support. Whilst recognising the amount of research already carried out and the international debate relating to the extension of systematic support practices, the project team needs to state the obvious: more roof and wall support in accurately designated danger areas reduces the consequence of roof and wall collapse.

    The NPI recommends the following changes to the support philosophy:

    - All sections of a mine should consider substantially increasing systematic support.
    - Consideration for additional support, such as meshing, lacing, w-straps, etc., in high-risk areas should be given.

- If necessary, this approach should be enforced by law.
- Any deviation from systematic support to a lesser support policy should be approved in writing, after investigation, by the regional director of the Department of Mineral and Energy Affairs.
- No mining official will have the authority, delegated or otherwise, to deviate from the norm, i.e. systematic support.
- More roof bolts (higher density) should be used to counteract the current (high frequency) occurrence of roof falls between supports. If feasible, a minimum density should be stipulated by law.
- Roof falls that occur where the roof bolts have fallen out could have been prevented by using longer roof bolts. If feasible, minimum specifications should be enforced by law.
- The mining industry should seriously consider using headboards and/or w-straps more often. Headboards and/or w-straps should be used at the slightest indication that the roof is more fragmented than expected, irrespective of whether sections "look" good or not.

- **INADEQUATE LIGHTING OF COAL FACE**

  Something should be done to make the coal face and newly exposed roof and sidewalls visible during mining operations. This aspect requires further investigation and should not be unduly delayed.

- **PERIOD BETWEEN EXPOSURE AND SUPPORT TOO LONG**

  Roof support activities should never fall behind and maximum periods between exposure and support installation should be specified in the COPs.

- **MAINTAINING PROPER COMMUNICATION METHODS**

  Mine management should ensure that all the communication methods are current, properly used and serving their intended purpose. Safety meetings, when and whatever the format, should not be repetitive, warning signs should be kept clean and visible, chevron tape and other warning materials and boards should be properly maintained and should never be used for other purposes.

- **CENTRALISED BASIC TRAINING**

  Attempts should be made at industry level to prepare a training programme that would develop the basic competencies required for safe work as well as the competencies required by first-line management, supervisors and safety representatives. Developers of this training programme should include labour, line management, safety officers and representatives, under the chairmanship of a training expert.

- **OTHER FACTORS THAT CONTRIBUTE TO ROOF AND SIDEWALL ACCIDENTS**

  - **Outdated technology for hazard recognition**

    If an instrument could be developed to read the physical condition of a roof to a depth of say 3 m, providing reliable data regarding cracks, slips, fissures, etc. in the rock, sandstone or coal, the number of accidents would evidently be negligible. Such an instrument would ideally present a photograph such as an X-ray.

    The NPI was informed that extensive research has already been done in this respect but that the results had been negative or at best clumsy and impractical. However, this is no reason to stop the research. The NPI would like to see this research continued, perhaps in collaboration with counterparts overseas.

  - **Availability of rock engineering discipline**

    The South African coal-mining industry needs many more rock engineers and rock mechanics on location at the mines. The NPI is prepared to state that unless this discipline is available at a mine for 24 hours per day, that mine runs at least a 25% increased risk of rock falls.

    Training of all mining employees in the principles of rock engineering should become a top priority. Courses, already in existence, should be offered to the various employee levels, with the emphasis on shift overseers, face bosses, team leaders, equipment operators and their assistants, the sounding stick and pinch bar operator, and the safety representative.

    The NPI recommends that surveyors and geologists who are already full-time employees at nearly all the mines, be given the opportunity to become multiskilled. They should be given the opportunity to become fully qualified rock mechanics. Courses could be offered, full-time, part-time or even partly by correspondence.

    Smaller mines who cannot afford or justify the appointment of a graduate rock engineer could benefit by employing a multiskilled surveyor/rock mechanic or geologist/rock mechanic and thus have this much-needed discipline at their disposal 24 hours per day.

  - **Superficial and uncoordinated recording of accidents and near accidents**

    A centralised database should be available where all accidents and near accidents can be recorded. The mines should be provided with a document that would ensure comparable information between mines. The documented information should be summarised by individual mines at frequent intervals and subsequently shared with employees. At mine level this information should be used for learning purposes.

    The Department of Mineral and Energy Affairs should also have access to the data. This would ensure an awareness of accidents and near accidents in other mines, the factors that caused them as well as precautions that had been implemented.

    This centralised database should be user-friendly and accessible to researchers.

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1. INTRODUCTION

Mining is the third largest industry in South Africa. Each day approximately 53 000 coal miners go underground to mine 200 million tons each year. Despite efforts to create a safe working environment, danger lurks everywhere - in the large machinery, the shuttle cars, the conveyors transporting the coal, and above all the roofs and sidewalls that are being mined. Accident statistics paint a grave picture of these ever present dangers.

Table 1 indicates the number of deaths caused by roof and sidewall accidents. What is very obvious is that there is no pattern in the statistics.

TABLE 1

ANALYSIS OF ANNUAL ACCIDENT STATISTICS
CHAMBER MEMBER MINES 1987 - 1995
COAL MINES

YEAR *	AVERAGE LABOUR AT WORK	TOTAL DEATHS	ROOF AND SIDEWALL ACCIDENTS	
			DEATHS	INJURIES
1987	60 472	74	28	70
1988	55 740	21	10	62
1989	56 458	18	15	79
1990	54 300	16	3	59
1991	49 667	17	14	48
1992	49 188	23	8	54
1993	40 599	22	14	43
1994	54 662	32	3	38
1995	56 621	17	13	48

During the past nine years an average of 25 miners died every year, and 229 were injured. In 45% of the deaths and in 24% of the reported injuries the cause was roof and sidewall accidents.

According to Boers (n.d.:30) the fatality figures in South African mines compare well with those of the Western countries, but this does not imply that we can become complacent about safety statistics. It must be kept in mind that only deaths and reported injuries are recorded in the table. The figures would differ significantly if all injuries and all near accidents were also recorded.

Getting a clear picture of the real situation is however impossible due to the way in which mines record accident data and because of the lack of a centralised database of accidents in South African coal mines. If any user-friendly database that provided recent information on accidents and near accidents did exist, mine management could learn from it and thus improve the situation.

Despite the fact that employees realise the potential danger of their occupation, some seem to prefer to ignore it. Accident investigations and data from interviews with coal miners indicate that there are individuals who in certain circumstances do not hesitate to go under an unsupported roof. This might be a way of coping with their fears or it might be their way of accepting the fact that they work in "the killing field", as somebody described it. This attitude is not conducive to safe behaviour and everything possible should be done to determine what the origins of this attitude and behaviour are and how both can be changed.

The primary objective of this project was to "identify the causes of unsafe acts or neglect resulting in roof falls and sidewalls accidents in coal mines".
In an attempt to identify these causes the following aspects were investigated:

- The reasons for or causes of unsafe acts or neglect as documented in the literature
- The perceptions of South African employees in this regard
- How South African employees are trained to behave in a safe manner
- How safety is communicated in South African mines
- The standards and regulations to ensure a safe working environment.

1.1 OUTLINE OF THE PROJECT

The project started in January 1996. With the help of three key role players in Simrac and the coal-mining industry, the mines and key role players to be interviewed were identified.

The following research processes were used to gather information from the available sources:

- A literature survey to identify international trends
- A questionnaire survey to determine the perceptions of employees in terms of the reasons for unsafe behaviour
- Interviews with key role players in coal mines and the coal-mining industry
- Observations during mine visits.

Ten key role players in the South African mining industry, including the chief mine inspector, rock engineers and employees from the Department of Mineral and Energy Affairs, were interviewed.

The following mines were visited:

- Welgedacht
- Leeufontein
- Tweefontein
- Blinkpan (Koornfontein)
- Durnacol
- Bank Mine
- Tavistock.

At these mines the mine management, senior operational employees, safety representatives and officers as well as senior human resources and training managers were interviewed individually.

Underground visits were arranged at all these mines. These visits enabled the project team to observe how the roofs and sidewalls are supported or not supported, and how employees and management interact.

Focus group discussions were arranged with:

- Miners
- Miners who have experienced mine accidents
- Union representatives.

A questionnaire was designed to obtain the views of more people than those interviewed. The questionnaire developed by the American Bureau of Mines was used as a basis. Additional questions which the project team thought relevant were added. The questionnaire was sent to the members of the project team and to the contact people at the mines we planned to visit for comments. All the comments received in time were taken into account when the final questionnaire was prepared. A copy of the questionnaire is included as Appendix 1.

At each mine which was visited, the contact person was requested to ask 200 literate employees to complete the questionnaire. The response was as follows:

TABLE 2

SAMPLE USED

MINE	FREQUENCY	PERCENTAGE OF SAMPLE
Koornfontein	49	12,8
Welgedacht	42	10,9
Goedehoop	16	4,2
Tavistock	112	29,2
Leeufontein	17	4,4
Durnacol	129	33,6
Tweefontein	19	4,9
TOTAL	386	100,0

The response from most of the mines did not meet the expectations and several attempts were made to meet the requirements of a representative sample. Eventually it was decided that the results were not sufficient to be regarded as representative of the different types of coal mines in South Africa, but that it provided useful information with regard to the perceptions of employees.

2. FINDINGS

The findings presented in this project are based on the outcomes of the research instruments that were used.

The findings will be presented as follows:

- Trends identified in the literature
- Perceptions of South African employees regarding the problem under investigation

- Training on safety
- Standards and regulations as implemented in the mines that were visited
- Conclusions
- Recommendations.

2.1 THE CAUSES OF UNSAFE BEHAVIOUR - A LITERATURE SURVEY

According to the literature, mine accidents seemed to be caused by:

- Unsafe environments
- Unsafe behaviour of employees.

2.1.1 UNSAFE ENVIRONMENTS

Until quite recently it was generally considered to be easier to prevent employees from performing unsafe acts through manipulation of the working environment than through training or motivational programmes. This approach postulated that it would be easier to redesign tasks and the working environment in order to remove employees from all sources of danger and to prevent situations from arising that would prompt them to commit unsafe acts than to present special training. However, the serious lack of skills and rock engineering knowledge is a major obstacle in the implementation of this approach. As was recently stated in a publication, "No matter how good the science, no matter how sound the technology used, both the theory and the engineering have to be implemented and consistently used on a day to day basis by people, many, if not most, of whom will have little or no knowledge of the intricacies of rock machanics or strata control engineering" (*The human element in rock engineering*, 1996:9).

Efforts to improve safety were therefore directed towards identifying and evaluating significant dangers in the expectation that, with knowledge of the hazards and the equipment to create a safe environment, employees would react accordingly. The number of mine accidents and the causes of these accidents led to the realisation that technology alone will not prevent accidents.

In the past decade there was a move away from this passive approach to a more active one that involved employees in their own safety. According to some sources (Cohen, 1987:299) the unions and employees did not favour this approach. They perceived it as shifting the burden of protection from the employer to the employee, because the latter's actions now determined the level of safety in the workplace. However, the approach did not imply that management would no longer create a safe environment; it only implied that employees would be enabled to play a more active role in their own safety.

2.1.2 UNSAFE BEHAVIOUR OF EMPLOYEES

Unsafe behaviour seemed to be caused by:

- Employee characteristics
- Characteristics of the work
- Reinforcement.

2.1.2.1 EMPLOYEE CHARACTERISTICS

Intensive research has gone into the reasons why employees, despite the safe environment that is created and their desire to be safe, behave in an unsafe manner. Park (1992) said in a recent article on human behaviour that there was too much emphasis on people having to behave "perfectly". It had to be accepted, he said, that **if humans were involved, errors would be made**, regardless of the level of training, experience or skill. There was an unfortunate tendency in industry to expect human beings, like machines, to become ultrareliable.

Ironically all the effort that is spent on designing these ultrareliable equipment and safe working environments is often negated by human behaviour (Park, 1992:990). Some researchers, like Kerr (1957), even postulated that there was an employee personality type called "accident prone", that is a permanent tendency in the individual to engage in more unsafe behaviour than the average employee. This led researchers to trying to distinguish between workers who were accident prone or who tended to err more, and those who were not.

Knight and Salvendy (1992:978) came to the conclusion that variations in behaviour among different operators and within a single employee arise from these general classes of employee characteristics:

- Experience and training
- Enduring mental and physical characteristics such as cognitive style and perceptual ability
- Transitory mental and physical conditions prevailing at the time of performance. These include:
  - Motivation
  - Temporary illness
  - Fatigue
  - Stress
  - Alcohol and other drugs
  - Hours of work, e.g. overtime and shift-work schedules
  - Physical, social and psychological working environments.
- Memory - short-term and long-term - also plays an important role in human error. High stress levels will contribute to their not remembering warnings given to them a short while ago or instructions given during training.
- Personal problems have a bearing on 75 TO 90 per cent of all industrial accidents. These problems could be marital, alcohol or stress-related, and even problems with children. Other areas of concern that affect employees and their performance at work could be a lack of assertiveness, burnout and poor interpersonal skills.

  Supervisors are often aware that employees experience personal problems and try to assist in the following ways:

  - Ignoring the problem in the hope that it will go away
  - Threatening the employee and acting aggressively
  - Covering up for the employee and thus creating the ideal environment for the problem to grow
  - Becoming the employee's "therapist" and therefore no longer managing objectively.

2.1.2.2 CHARACTERISTICS OF THE WORK

Park (1992:993) postulates that people err because of:

- Task complexity. Some employees do not have the capacity to perform the tasks required of them.
- Error-likely situations. These are identified as work situations where the human engineering is so poor that errors are likely to occur. These situations overtax employees in a manner that is not compatible with their capabilities, limitations, experience and expectations. This work situation approach is rooted in the human engineering design philosophy that the working environment should be adapted to the employees and not vice versa. Errors will further increase under the following conditions:
  - Inadequate work space and layout
  - Poor environmental conditions
  - Inadequate human engineering design
  - Improper use and operation of the safety system
  - Work habits that could unnecessarily increase an employee's risk of injury not identified
  - Lack of awareness and recognition of workplace hazards
  - Lack of acceptance and use of protective devices
  - Non-observance of housekeeping and maintenance measures
  - Improper responses to emergency situations.

2.1.2.3 REINFORCEMENT

Another approach is that unsafe employee practices persist because they are in some way naturally reinforced. Reinforcement takes place for the following reasons:

- The task may be completed **faster** with consequent higher earnings or praise from the supervisor, or completion could signal the end of a less preferred task so that the employee may move to a more preferred activity.
- Accomplishing a given task with **less effort** also plays a reinforcing role. For example, miners should set temporary roof supports if they have to work in areas where permanent forms of roof support have not yet been installed. However, setting an adequate number of temporary supports may require substantial effort and in certain circumstances some employees neglect to perform this precautionary action. A frequently cited reason for neglecting to set temporary supports is that the person was tired or in a hurry.
- The **negative consequences** of unsafe behaviour might be negligible, delayed or infrequent, leading to statements such as "It really is not very smart of me to do this. One day it could catch up with me".
- **Adhering** to safe work practices often **does not result in any meaningful, positive reinforcement**. Absence of injury or damage is hardly an effective reinforcing event. It has to be supplemented by others, e.g. meeting safety targets or even a tangible reward such as money.
- The **perceptions** of mine workers of the **consequences** of both safe and unsafe acts play an important role, whether these consequences are positive, aversive, potentially hazardous, immediate or delayed, frequent or infrequent, mild or intense.

2.1.3 MINE MANAGEMENT

As in any other organisation, mine management is ultimately responsible for the health and safety of its employees, and mine management includes first-line management.

In two recent mine accidents in South Africa, the quality of management was identified as the cause of the accidents. The chairman of the Harare and District Mining Association, Bill Teasdale (1995), confirmed this problem when he said that investigations into mining accidents indicated **inadequate supervision** as a major contributor to mining accidents.

Braithwaite (1985) also believes that the day-to-day management constitutes a problem, but so does **inadequate planning for contingencies**. He found that managements diligently work out the details of mining operations, but respond in an unplanned and unstructured manner the moment an emergency occurs. Instead of preparing to replan and redesign, they revert to a crisis management mode. He regards this as another significant contributor to death and injury in mines.

Another management issue that recurs in the literature and in conversations was an unclear **line of responsibility**, specifically with regard to safety. Employees were often unsure about who was accountable for which aspects of safety performance. There was a consequent lack of cooperation in identifying safety issues and employees did not know where to report accidents. Management is not only responsible for creating a safe working environment for employees, but is also responsible to the owners for managing the mine profitably. Some mine managements seemed to consider safety and productivity as trade-offs. Braithwaite (1985:169) studied this phenomenon, however, and he found that the most productive mines were also the mines with the least accidents and fatalities. He feels that this is quite understandable because they share the same sire, i.e. competent management.

Several authors and key role players in the mining fraternity concluded that not all managers are **committed to safety**. This is reflected by the time and resources they devote to improving safety. In one interview the mine manager openly stated that he paid miners a fee because they worked in dangerous conditions. By accepting that fee, they accepted their working conditions. He was not unwilling to create a basically safe environment, but felt that safety was overemphasised.

Cohen, Smith and Anger (1979) identified six factors that would indicate whether management is committed to safety:

- The rank and stature of the safety officer, the inclusion of safety issues at board meetings, and the frequency of personal inspections of work areas by top management
- More open, informal interaction between management and the workers and frequent everyday contact between the workers and supervisors on both safety and other matters. Such interaction would provide increased opportunities for early recognition of hazards, a freer exchange of ideas in correcting problems and consequently greater worker participation. It was found that management contact with workers in mines with poor safety records was more formal, less frequent, and largely confined to safety committee or other worker/management meetings.
- A stable workforce and evidence of personnel practices that would promote such stability. The latter included well-developed election, job placement and advancement procedures. These mines also provided individual counselling in handling problem employees, including violators of safety rules.
- Better housekeeping, orderly operation, and adequate environmental control of heat, noise and dust
- Training that emphasises early indoctrination and follow-up instruction in safety matters
- Added features or amended conventional safety practices to enhance their effectiveness. Near accidents as well as actual accidents were investigated. Safety signs were especially tailored or designed to depict conditions of concern.

We concluded that, according to the literature, the safety climate in a mine is created by the mine's management style. The processes that are used and participation will determine how safety-conscious employees are. The management style will determine whether production is more important than safety. Productivity and safety can co-exist.

2.1.4 TRAINING

A study of the literature on the role of training in mine safety indicated that most authors felt that proper training would solve safety problems. According to the authors who had been studied, training problems could be assigned to three groups:

- Lack of a common language and illiteracy
- Absenteeism among the miners
- The structures of training programmes.

2.1.4.1 LITERACY AND LANGUAGE

The issue of language, and indeed literacy, is a major problem for the majority of miners. A large number of miners are illiterate and therefore cannot benefit from written instructions, letters, warning signs and training manuals. The result is that miners do not understand what has to be done or how to do things correctly. Fanagalo as a language for miners was short-lived because it has a limited vocabulary and is unable to convey subtle meaning.

Due to the fact that miners often have difficulties in understanding instructions, ABE programmes often start with learning a common language. Smith (1993:36) refers to a case study that illustrates that non-English-speaking employees do not necessarily want to learn the common language. These employees are often in dire need of work and therefore lie about their ability to speak English. The problem is that miners who do not fully understand their safety training are walking time bombs.

Employees do not want to learn English, and some of them do not want to be assimilated into a new culture. They consequently resist all attempts to teach them English. Experienced translators and interpreters should therefore be available, or the employee's language should be learnt. Another problem is that some terms do not have equivalents in the black languages. Practical classes and simulated situations could save the day. The validity of written or even oral examinations is also in question. Smith (1993) and several other researchers suggest that practical examinations would provide a more valid indication of an employee's understanding and ability to make decisions about the dangers facing him.

2.1.4.2 ABSENTEEISM

The second obstacle stems from retraining. This is required because of ordinary absenteeism and the fact that migrant workers from neighbouring countries and employees from rural areas take extended leave. When they return to the mine they receive an update on the work they do, but the training cannot solve the problem of unfamiliarity with the work area.

Lack of familiarity means that the worker has little or no knowledge of the unique properties of his machinery, materials, the working environment, the mining habits of his fellow workers, and programmes. This lack of familiarity gives rise to more dangerous conditions that, in the absence of compensatory care taken by the miner, would contribute to a higher accident rate.

Unfamiliarity affects three types of employees in coal mining:

First, as the physical characteristics of a mine section change from day to day, a worker who returns to the mine will not be familiar with the workplace and - other things being equal - would be more likely to have an accident.

Second, miners typically work in the same job in the same section, day in and day out. When a miner is absent for some reason, another is generally assigned as a replacement. This person would be less familiar with the work setting and - other things being equal - would more likely have an accident.

Third, in a typical crew configuration most mining activities require coordination among pairs of individuals who work closely together; e.g. the miner operator and the miner helper, the roof bolter and the bolter helper, and the two shuttle car operators. The worker next to the replacement miner could be placed in a more dangerous position because he would be unfamiliar with the replacement's mining practices. This would have an impact on the coordination of common activities in an inherently dangerous environment. Hence the theory is that this adjacent worker or the partner of a replacement miner would be more likely to have an accident.

2.1.4.3 TRAINING PROGRAMMES

The following problems have been identified in safety training programmes:

- Inadequate attention to the training requirements of a particular situation
- Unsuitable training methods and methods that have not been adapted to new training practices
- The evaluation of learning
- Operational training that is not integrated with safety training
- The superficial nature of training
- Accidents and near accidents are not utilised as learning experiences.

The following guidelines had been developed to improve the available training (Goldstein, 1975; Fredrickson, 1982; Weinstein, 1987; Smith, 1993):

- Assess the working conditions and operations as well as an employee's current behaviour. Particular attention should be paid to worker actions that are perceived to be risky.
- Involve employees in the development of a training programme's content, how it should be taught and how trainees ought to be involved.
- Prioritise those behaviours and job conditions that are perceived as the most hazardous. This list should serve as a basis for selecting behaviour-related objectives. The following practical issues should be considered:
  - How difficult would it be for employees to make the indicated behaviour changes?
  - Would these changes conflict with current practices?
  - How difficult would it be to maintain these changes?
- Inform workers about the need for job procedures that emphasise safety practices and how such procedures affect them.
- The order in which material is presented should match the steps employees follow in their daily work.

- Correct behaviours should be clearly demonstrated and employees should participate to enhance maximum carry-over from training to the work situation. Utilise accidents and near accidents as part of the training.
- Most of the training time should be spent on those behaviours that will have the biggest impact on the safety situation.
- Trainees must be motivated to behave in the required manner. Approaches to trainee motivation should, however, also include rewards that are contingent on the display of desired behaviour. Reward group adoption of new norms.
- Develop well-defined performance goals during training that will encompass these behaviours.
- Modify management practices and standards to maintain new behaviour.
- Give feedback to trainees about their impact on the safety situation and discuss their performance.
- Feedback should be presented in such a way that trainees will know what they have done right or wrong. It should offer constructive criticism and additional information about the situation and the required behaviours.
- Use over-learning in a well-defined manner. Frequently repeated drills on specific issues will ensure that the workers are not affected by factors such as stress and tiredness when critical decisions have to be made.
- Assign a trainee or trainees to a group with a good safety record, thus supplying social support for safe behaviour.
- Address individual learning ability through one-on-one training or programmed instruction.
- Safety training should be part of an integrated management programme to optimise operational effectiveness.
- Train supervisors and safety officers in on-the-job training so that they may be used as on-the-job trainers of safety practices.
- Provide feedback on observed behaviour to maintain the learnt behaviour. Safety records and records of the observed behaviour should be displayed in the meeting area of the group.
- Safety training should also include:

    - Acceptance and proper use of all personal protective equipment
    - Identification of hazards and consequent behaviour
    - Legal issues
    - Accountability of all employees
    - Impact of accidents on performance.

- Analyse the working conditions or operations and the related worker behaviour before the behavioural targets are selected. Particular attention should be paid to worker actions that are deemed risky.

2.1.5 COMMUNICATION

The definition of communication - a sharing of meaning - makes one realise that communication problems are unavoidable, and these problems will in turn unavoidably contribute to roof and sidewall accidents. Braithwaite (1985) found that in 48% of all the mine accidents he researched, inadequate communication of mining plans, potential hazards and inadequate reporting lines had contributed to the disaster.

Based on the literature it was concluded that communication contributes to neglect in the following ways:

- Lack of a common language: Employees do not understand instructions or safety talks
- Illiteracy: They cannot read warnings and sometimes do not even understand visual warnings
- Unclear communication lines
- Habit: The same type of talk at the same time every day
- Inadequate communication skills of supervisors, safety officers and safety representatives
- The way accidents are recorded.

Cohen et al (1979), McGuire (1969), Leventhal et al (1966), Weinstein (1987) and Ivin et al (1994) identified several factors that should be taken into account when communication plans aimed at safe behaviour are developed. These factors can be grouped into the following categories:

- Preparation
- Message development
- Message delivery
- Communication networks and participation.

2.1.5.1 PREPARATION

Current thinking in the communication field believes that the audience is an active processor of information, one that perceives and construes threats from its own frame of reference and copes with dangers that are consistent with its perception and understanding of the risk. It is therefore imperative that efforts should be made to determine the following:

- The miners' existing level of knowledge (or misinformation) about the workplace hazards in question
- Their perceptions of the hazard in terms of the everyday performance of their jobs and the benefits of protective measures to reduce the risk
- The level of education, age, and length of service that could affect the miners' understanding or acceptance of the message to be developed.

Employees' information needs about the dangers around them could include the following methods:

- Direct observation of their work behaviours to determine whether they deviate from safe practices
- Verbal questioning of employees to clarify their perceptions of risks and to determine their appreciation of control measures.

2.1.5.2 MESSAGE DEVELOPMENT

The researchers emphasised that messages should only be developed after the research has been done. In addition to the research conclusions, the following aspects should also be attended to:

- The credibility of the message source and the perceived expertise and trustworthiness of the persons and the organisations involved in health hazard concerns
- The supervisor proved to be an excellent communicator because of his role as a change agent:
  - He has come up through the ranks and the work group members know him
  - He has technical knowledge and experience and will therefore understand the constraints under which employees have to work
  - However, he often lacks communication skills
- The detail provided about operations, workplace locations and exposure factors that present the greatest hazard
- The use of understandable and meaningful terms to describe the nature of the hazard and risk estimates
- Communication statistics on safety that refer to a specific group at the plant will have a greater impact than general information
- Persons in the target audience for safety communication programmes should be represented in the group who is planning the effort
- Messages informing workers about lurking dangers should be separated from those used to motivate worker compliance with protective work practices
- Employees' responses to dangers are highly dependent on their perceptions of personal vulnerability and beliefs about their ability to control outcomes. Hence messages that provoke fear can provide motivation to act, but only if the recommended actions are considered an effective means of controlling the fear. Providing specific instructions on how to perform the recommended action strengthens employees' intentions to adopt that action
- The bulk of the research indicates that the spoken word has a more persuasive impact than the written word, and that informal face-to-face communication is superior to any communication medium. The greater effectiveness of face-to-face communication is ascribed to its being two-way, which increases the participation of the receiver, and probably because it commands more attention than other media. Two-way communication is therefore more effective in gaining worker acceptance.
- The perceptions of the group will have a significant impact on the behaviour of the individual (McGuire's, 1969). This conclusion suggests that social support could be critical in worker compliance. Directing safety appeals to the workers' families to increase safety consciousness among workers embodies this idea but research in this regard yielded inconsistent results.

2.1.5.3 MESSAGE DELIVERY

Communication researchers found that the following aspects should be taken into account when the message is delivered:

- It is more effective to use multiple messages at intermittent intervals than mass single-dose transmissions
- Use different communication channels to ensure that the media preferences of all employees are met

- The most potent messages are delivered by communication media and complemented by important other people, e.g. the foreman, union representatives, management and the family of the employee.

2.1.5.4 COMMUNICATION NETWORKS AND PARTICIPATION

When all the above communication issues have been dealt with efficiently, the message could still fail because of an ineffective communications network. A network has two objectives:

- It should enhance the participation of employees in safety issues
- It should ensure that potential hazards can be reported quickly, accurately and to the appropriate person.

Two case studies from Australia proved that an effective communications network can improve the safety behaviour of employees.

In Western Australia, Alcoa and Worsley Alumina have established successful safety communication and management programmes built around strong worker participation (Irwin & More, 1994). At these mines management participation is regarded as central to accident prevention programmes. Senior managers accept that they are accountable for safety and that they have to provide guidance in an environment that fosters communication, involvement and teamwork.

This commitment to participative management is supported by careful selection of the managers, followed by extensive training programmes to develop the necessary competencies for participative management. The competencies targeted for attention include team-building, dealing with conflict, and understanding organisational change.

In communicating awareness of safety issues and safe practices, these mines planned and implemented a variety of participative safety activities:

- **Safety committees**. This mine allows two-way communication and inputs at health and safety discussions by a substantial proportion of the workforce.
- **Safety representatives**. Safety representatives work with the foreman in an attempt to prevent accidents and near-miss incidents. In time, these safety representatives will be replaced by a system where every work crew member is equally trained and involved.

- **Safety representative training**. The training course was designed by a task force consisting of management and wage employees. Widespread employee involvement has contributed to effective two-way communication on safety issues.

- **Crew safety plans**. Crews were encouraged to develop and manage their own safety plans. They set objectives, determined strategies, developed action plans, monitored progress, and reacted appropriately to modify plans.

- **Project safety reviews**. Preliminary drawings are made available to all employees in the working area and advice is sought about safety issues. Designs are modified on the basis of this feedback.

- **Accident investigations**. These investigations are formal but participative, and employees are encouraged to play a major role in determining accident causes and follow-up action.

One employee summed up the changes that resulted from these activities: "We have come from a reactive, short-term, 'gimmicks and posters' safety programme to a more professional, proactive system, based on participative and continuous improvement." Communication, and communication management, have been central to these positive changes.

2.1.6 STANDARDS AND REGULATIONS

It is interesting that standards are not often mentioned in the literature. References to rock engineering information, rock engineers and safety officers are frequent, but not the actual quality and accessibility of mining standards and codes of practice.

Aspects which seemed to play an important role with regard to standards and regulations were:

- The Mine Health and Safety Act
- Punitive approaches
- Mine inspectors

2.1.6.1 THE MINE HEALTH AND SAFETY ACT

The new Mine Health and Safety Act in South Africa reflects a fair set of responsibilities for government, employees, managers and owners. The burden of proof required has been reduced from "beyond reasonable doubt" to "on the balance of probabilities", which makes obtaining a conviction easier.

The new act provides for:

- Elected health and safety representatives to participate in all safety management systems at the mines. The workers will be able to elect a full-time health and safety representative to carry out this task with full pay.

- Joint health and safety committees made up of elected workers and senior management officials, with the power to implement policy decisions

- A revamped mines inspectorate which will, in effect, create an expanded government agency made up of people who are experienced in occupational health and industrial hygiene

- A mandatory system of risk assessment at every mine. This obliges managements to identify potential hazards and to design systems that would eliminate, control or minimise the risks. (The risk assessment system is linked to the controversial clause which makes managements criminally culpable for fatal accidents unless they can prove that the procedures outlined in the Act had been complied with.)

- The right of workers to a free flow of information about risk assessment, accident statistics, codes of practice, accident enquiries and occupational disease statistics

- The right of workers to refuse to work if they have "reasonable justification" for believing that a serious danger exists

- Hazard awareness training for workers before their employment commences, at regular intervals, and before any major changes are made to the production process.

This new act could contribute to improved relations and improved safety, but only if it is managed properly, and if investigations are properly conducted by qualified people.

2.1.6.2 PUNITIVE APPROACHES

Braithwaite (1985), who researched various ways of enforcing mine safety, came to the conclusion that no society has ever adopted a truly punitive approach to the enforcement of standards and other regulations. According to this researcher there is a tendency to increase punitive measures, especially in the United States and Australia, in New South Wales in particular, and in Japan. Such measures are usually introduced after a major disaster. There is a feeling however that the fines that are imposed on the guilty do not have the necessary impact.

On the other hand punitive measures in Great Britain and France tended to drop. Some cynics say this is evidence of the government's inability to regulate. Less cynical individuals refer to a general trend away from punitive measures to persuasion. Clinard and Meier (Braithwaite, 1985:88) came to the conclusion that punishment may work best with individuals who are future-oriented and who are therefore worried about the effect of punishment on their future plans and their social status.

2.1.6.3 THE ROLE OF MINE INSPECTORS

Mine inspectors play a crucial role in the enforcement of standards and regulations. In 1985 the US Mine Safety and Health Administration employed some 14 000 mine inspectors. Japan had 110 of whom half were university graduates for 32 mines. In South Africa the situation is totally different.

Eight job advertisements in the past year failed to entice a single suitably qualified mining inspector. But it is not lack of skills that keeps the mines inspectorate 20% understaffed; it all comes down to an ineffective reward system. Mine inspectors claim they cannot be proactive because they are already overloaded with accident investigations. If the new mining act is to be effective, a "beefed up" safety inspectorate would be critical, because the new legislation on its own will not save lives. This, interestingly enough, was also one of the major problem areas identified in the report by the Mining Regulation Commission in 1925 - and still the problem has not been solved.

According to Braithwaite (1985:77) there is a high correlation between the number of mine safety inspectors and a decline in fatalities. It was also found that the moment a mine got its own mining inspector, the accident rate dropped to below the national norm. Research established that a punitive style soon made the inspector an outcast. Consequently an inspector often experiences a conflict of interests. Braithwaite (1985) suggests that a persuasion approach be followed: Instead of documenting the mistakes and potential dangers, the inspector should address them immediately, if possible in conjunction with the particular person, or deal with the problem himself. Not only is this approach more cost-effective, but its impact is also far greater.

One of the major problems identified in connection with standards and regulations is the way in which accidents are investigated. The main objective of investigations seems to be to "fix the blame". If the investigation team is successful in finding someone to blame, the chances of something significant happening to the guilty party are rather slim. More effort should instead be put into identifying the reasons for the accident and into providing guidelines to prevent similar accidents from recurring. Implementation of such guidelines should adhere to a specific time frame, after which the situation should be inspected by an official who is in a position to take action if the guidelines had not been followed. Every accident would consequently be a learning experience for the specific mine as well as for the industry itself.

Hopkins (Braithwaite, 1985:97) came to the conclusion that miners rarely experience really serious accidents. Consequently they often regard the standards as somewhat arbitrary and unnecessarily stringent. What happens is that miners develop their own safety standards based on their own experience, and these standards diverge from the official version. Unfortunately, since the experience of one particular group of miners is limited, their experience-based standards do not leave room for exceptional events or circumstances as official standards do.

Most mine managers agree that they need mine inspectors for exactly that reason. In other words, competent mine managers, says Braithwaite (1985:97), realise that they and their workers do fall victim to standards based on their own limited experience and to policies which deal with day-to-day problems while the possibility of potential catastrophes is neglected. The safety inspector is the person who should draw the attention of the mine manager to contingencies that could lead to accidents. However, Braithwaite does acknowledge the fact that mine inspectors are resented because they are perceived as intruders by the mine managers.

2.1.7 IN CONCLUSION

The literature survey revealed a wealth of information on the role of the human element in accidents and on ways to change unsafe behaviour. The recommended strategies will be based on this information.

2.2 PERCEPTIONS OF SOUTH AFRICAN EMPLOYEES

This section contains the views of the miners who participated by completing the questionnaire and those who were interviewed during the project.

2.2.1 FREQUENCY OF UNSAFE ACTS

46,2% of the employees indicated that some of them frequently go under unsafe roofs. The employees who were interviewed corroborated this result. They indicated that employees were aware of the danger but somehow chose to ignore it. The questionnaire respondents indicated that 83,6% of those employees who ventured under unsafe roofs were aware that they were doing so.

- The artisans expressed the strongest feelings about employees who frequently ventured into unsafe areas and the mine overseers were convinced that they knew that they were in unsafe areas.
- The support staff were convinced that they did not know about the dangers.

2.2.2 GOING UNDER UNSAFE ROOFS

At all the mines the employees who were interviewed indicated that all workers should be aware of going under unsupported roof.

- These unsafe areas were usually clearly marked or fenced off with wire, mesh, chevrons or chevrons hanging from roof bolts to mark the last row of support. At one of the mines the workers said that unsafe areas were marked with red material because chevrons easily get lost, are blown away or removed by employees.

- At most mines the employees reported that in the green areas or waiting areas they were from time to time verbally reminded not to go under unsupported roof.

- The opinion was expressed by some of the team leaders and miners that employees were aware of doing just that, because they were very strict with them. Newly appointed employees were closely supervised and would be reprimanded for such unsafe behaviour.

However, workers sometimes removed the safety barriers without informing the next shift. In that case workers were not necessarily aware of going under unsupported roof. The workers usually took the wire home.

The mine employees who completed the questionnaire were adamant that they would not go under unsupported roofs to impress anybody and denied that their supervisors expected them to do so. They also indicated that their supervisors cared significantly more for them than the mine management did. They also felt that the employees cared more about safety than about production.

Employees with different job titles and in different age groups indicated the following:

- The mine overseers were the most reluctant to go under unsupported roof and the miners were the most likely to do so.
- The shift overseers were the most positive about their supervisors and the engineers the most negative. Artisans felt the strongest that mine management did not care for them.
- Young employees and those who had recently joined the mines were more negative than the older employees and those who had joined more than six years ago. They seemed to be asked more often to venture under dangerous roofs and they felt the most negative about the relationship with their supervisors.
- The older employees (46 and older) were the most positive about management and supervisors.

2.2.3 REASONS FOR GOING UNDER UNSAFE ROOFS

The questionnaire respondents said that employees go under unsupported roofs for the following reasons:

- They have to do inspections (60%).
- They think they will only be there for a short time (48%).
- They have to do work there (45%).
- It is a short cut to another place (41%).
- They see other miners do it (33%).

However, the miners would not be willing to go under unsupported roofs just to impress their colleagues, or because their supervisors told them to do so, or because they wanted to increase production. They might go there for these reasons, but it would be less frequently than for the other reasons.

It is interesting that employees at all the different job levels indicated that inspections would be the main reason why employees went under unsupported roofs. The second most important reason for doing so differed between the job levels:

- Support staff did so because their supervisors instructed them to go there.
- Shift overseers apparently felt complacent about going under unsupported roofs. They saw other employees do so and not being harmed, and consequently they did not mind going there.

- Employees at all the other job levels were willing to go under unsupported roofs because they were sure they would not have to stay there for long.
- Another interesting finding was that employees who were younger than 30 years and those who had joined the mines between six to eight years or less than two years ago seemed to go under unsupported roofs more frequently than other groups.
- The age group 31 to 45 and employees who had been working on the mines for more than nine years did not think they went under unsupported roofs as frequently as the other groups did.
- Younger miners, those younger than 31 years, indicated that the second most important reason why miners went under unsupported roofs was because they assumed it would only be for a short while. Those who were older than 45 years said that it was because they wanted to take a short cut.
- The same applied with regard to the time they had been working for the mine.Those who had worked on the mines for less than eight years would go under unsupported roofs because they expected to be there for only a short while. Employees who had been on the mines for more than eight years felt that miners mainly went under unsupported roofs because they worked there.

It appeared from the discussions that the main work-related reason for going under unsupported roof was to carry out inspections. It was interesting, however, that these inspections were conducted in different ways at different mines. At some mines inspections took place before the shift, and in others after the shift had started. Different people were involved in this procedure. Those mentioned by the miners included the face boss, the workers responsible for testing gas and water, the safety representative, the shaft steward, the roof bolt driller, the team leader and the safety representative.

Production seems to be a major reason for forcing employees to go into unsafe areas. Even though this cannot be generalised, supervisors seem to put pressure on employees to produce more, which implies that they have to venture into unsafe areas. It was said that some supervisors tried to save time when they drew centrelines by sending workers under unsafe roofs to speed things up instead of making the roof safe first. According to some employees these situations occurred because the workers were generally afraid of their supervisors and therefore they obeyed them. Not going under the unsupported roof when ordered to do so would be perceived as disobedience.

Other workers expressed the opinion that their supervisors would not allow them to go into unsafe areas, except in certain exceptional instances. In these instances the supervisor had to sign the instruction in the shaft steward's book. Most of these commands were to execute inspections and were therefore necessary.

Although personnel were not identified as a major problem area during the quantitative survey, the miners who were interviewed felt that there was cause for concern. Despite the fact that supervisors tried to identify employees who were not well or under the influence of some drug or alcohol, it was not always possible to deal with all these problems. Problems mentioned in this regard were:

- Tiredness, especially over weekends after driving long distances from home
- Workers in the hostel who did not get enough sleep because they were disturbed by room mates
- Hangovers and the use of dagga
- Differences between ethnic groups, or fights between individuals
- Employees who are far away from home tend to think about their families, death or illnesses, and lose concentration at work
- Stress during night shifts, especially Sundays.

Employees indicated that they sometimes went into unsafe areas because they were in a hurry - especially during the short shift on Saturdays and on paydays.

2.2.4 REASONS WHY SUPERVISORS IGNORE UNSAFE BEHAVIOUR

The respondents were asked to indicate why supervisors ignored employees who ventured under unsupported roofs. The main reason seemed to be that supervisors tended to do the same and because they were so busy with other things that they did not have time to confront the culprits. The third most important reason was the attitude among supervisors that the miners were adults and knew they were taking a risk, so it was not the supervisor's responsibility to talk to them about it.

It is interesting that the other job titles perceived the reasons for the supervisors' behaviour in a totally different light:

- The mine overseers and engineers felt that it was because the supervisors did the same, the shift overseers said it was because the supervisors were too busy with other things, the miners, artisans and support staff replied that the supervisor felt that the employee would in any case not listen to him.

If age is taken into account, this was also how the miners younger than 35 and those older than 36 saw the issue.

- Miners in the 36-45 age bracket felt that it was because the supervisors were too busy, and the younger age groups felt it was because the supervisors did so themselves.

The mine employees appeared to be convinced that most supervisors would not ignore employees who went under unsupported roofs. If they did, it would probably be because they sent them there for production reasons or because they did not have the courage to do so themselves. It was therefore clear that no external forces caused supervisors to ignore unsafe behaviour - if they did, it would be because of personal characteristics.

2.2.5 THE IMPACT OF STANDARDS ON UNSAFE BEHAVIOUR

The respondents were asked how they felt about safety standards, about the employees' level of understanding of standards, and the impact of standards on accidents.

The employees were convinced that everyone in their section or work area understood the safety standards, that these standards were adhered to, and that all of them were familiar with the mine's safety code of practice. They did indicate however that even if the standards were carefully implemented, it would not prevent all sidewall and roof fall accidents.

- The miners felt the strongest about the preventive role of standards and the mine overseer was the least convinced.
- The support staff were the most positive about the level of understanding and the mine overseer the least convinced.
- The miners felt the strongest that these standards were adhered to and the engineers felt the least so.
- The shift overseers and artisans were convinced that employees were familiar with the safety code of practice and the engineers were again less convinced that they were.
- The engineers felt that employees were involved in the formulation of safety practices and the mine overseers and artisans felt they were not.

The employees who were interviewed also thought that most employees understood the safety practices. Understanding was ensured by frequent discussions and worker involvement in developing them. It was frequently mentioned that the standards were discussed in the waiting areas before shifts and during safety shift breaks. Despite these discussions the most common concern was that some employees still did not understand these safety practices because they did not fully understand the language. Another major obstacle was their inability to concentrate. The general feeling was that these problems were part of the supervisor's reality and he therefore had to take care of these people.

Two other major causes for concern were identified during discussions about the employees' understanding and involvement in safety standards. The research team came to the conclusion that the representatives of the different unions were reluctant to become involved in the development and explanation of safety standards. They seemed rather to focus on other issues and not on ensuring that a safe working environment was created.

Due to a number of reasons, among others mechanisation, employees were retrenched. However, mine management still expected the same tonnage. So, despite the fact that employees might know and understand all the safety standards and codes of practice, neither was adhered to. Adhering to these practices were perceived as a luxury that mine management did not allow employees to enjoy.

2.2.6 THE ROLE OF COMMUNICATION

The respondents had to indicate how they perceived the role of communication in creating a safe mining environment. They were very positive about the way the supervisors discussed safety issues and hazards before shifts. They also indicated that they had access to safety statistics as these data were posted on the notice boards. Two problems with regard to communicating safety issues seemed to be that dangerous areas were not marked properly, and the role of the safety representative in communication.

The different job titles perceived the role of communications as follows:

- The mine and shift overseers and the engineers were the most positive about the communication issue and artisans and support staff were the most negative.
- The safety representative was a major source of information for support staff, and the mine overseers were very negative about their role in communication.
- The engineers were particularly negative about the way hazardous areas were indicated, and the miners had no problem with this aspect. It might be a case of if you don't know, you don't know.

Employees older than 36 years regard their supervisors as a more important source of information than those younger than 36. The safety representative seemed to be a more important source of information for that group. Another distinction which could be made along the same lines dealt with the way dangerous areas were indicated - the younger the employee, the more critical they were. This might be because the older employees recognised the signs more easily.

The employees who were interviewed reported that safety was definitely discussed. However, there were a number of problems:

- Employees did not necessarily understand the discussions.
- The methods used to communicate dangerous areas were made ineffective by dust, insufficient light, employees removing the signs, and machinery which damaged these indicators during operations.

- The safety representatives and safety officers who were supposed to be key communicators and role players in the communication network were unable to fulfil their role, due to skills and power base difficulties.

2.2.7 EMPLOYEES' PERCEPTIONS ON TRAINING

The employees were asked to evaluate the safety training they received. The general response was very positive. The training dealt with relevant issues and new knowledge could be applied.

The responses from the different job titles and age groups indicated that:

- The miners and the support staff were the most positive about the training provided.
- The engineers were the most negative.
- Employees younger than 25 years of age were the least impressed with the training they received. Those who had just joined the mines indicated that they found the training difficult to implement.

Most of the employees who were interviewed indicated that better training about the dangers of unsupported roofs and sidewalls would help prevent unsafe behaviour and accidents. They said they needed more practical courses and induction training, as well as on-the-job training to make better judgments. They wanted to be empowered by safety knowledge. Some employees indicated that specifically rock mechanics-related training had to be offered.

However, other employees indicated that training would not make any difference because the problem was caused by the employees themselves and nothing could cure that.

2.2.8 PREVENTING ACCIDENTS

The respondents were given a list of ways in which accidents could be prevented. They thought that accidents could best be prevented by means of training (87%), more warning signs (85%), and unannounced visits (84%). The least effective ways would be to assign employees to safety-conscious groups, to impose fines, and to post the names of the culprits on notice boards.

The job titles responded as follows:

- The engineers were the only employees who felt that training was not of primary concern in preventing accidents; they felt the solution was to use more warning signs.
- Posting warning signs was also preferred by the shift overseers, miners and artisans.
- Only the miners and support staff felt that unannounced visits would not encourage safety consciousness.
- The mine overseers, the engineers and support staff said that a system allowing employees to report culprits would have a positive impact.
- The mine overseers and the miners also indicated a preference for disciplinary steps against people who behave in an unsafe manner.
- The engineers also felt that employees who behaved in an unsafe manner should be reported to the union.

The age groups and the length of service at the mines were unanimous about methods to prevent accidents - training, warning signs and unannounced visits. When the different age groups were compared, the following came to light:

- Older employees had the most faith in training and unannounced visits.
- Those in the 36-45 age group had the most faith in a system to report employees, disciplinary steps and reporting them to the union.
- The age group 31-35 wanted a more punitive approach - fines should be imposed on employees and foremen, names should be posted publicly, crews should be reported and the union should be informed of unsafe behaviour.
- The 26-30 age group had the most faith in disciplinary steps against the employees and the foremen.
- Employees younger than 25 years expressed the least faith in training and disciplinary steps.

The following were established during the interviews:

Most team leaders and section supervisors were in favour of reporting employees. The purpose of the reporting should not be punitive, but to send them for training. They expressed the belief that such a reporting system would improve the safety-consciousness of all employees.

The idea of fining employees or supervisors who behaved unsafely was not well received. Employees generally felt that fines would cause negative attitudes and would not increase safety-consciousness.

Attitudes regarding disciplinary steps against employees and supervisors differed. Some felt that it could not improve the situation, whereas others felt that it would indicate how serious management was about safety issues. Those in favour of disciplinary steps also felt that the supervisors of employees who behaved unsafely should be fined to improve their supervisory skills.

Reassigning employees to groups with a history of safe behaviour was not perceived as a solution. They thought this person would have a negative influence on employees in such groups. If they had to be reassigned, it should be to surface work.

Posting warning signs would improve the situation but these signs had to be mentioned or they would in time lose their effectiveness. Employees removed these signs, dust gathered on them and they were damaged by machinery.

Although unannounced visits had a very positive impact on the safety behaviour of employees in other industries, the mine interviewees were quite negative about this suggestion. They felt that the sections were the responsibility of the supervisors and visits had to be arranged. One got the impression that the interviewees feared the consequences if management really knew how things got done at the rock face.

2.2.9 IN CONCLUSION

Despite the fact that only a small sample of mining employees participated in the survey, the mining fraternity agreed that the views of this sample represented those they had come across. The research team therefore feels that these views represent the views of South African mine workers in general.

2.3 SAFETY TRAINING IN SOUTH AFRICAN COAL MINES

2.3.1 INTRODUCTION

One of the research team members was dedicated to investigating the way employees in coal mines were trained to ensure that they would behave safely. Training centres were visited, interviews were conducted with human resources and training officials, and with employees in general.

2.3.2 SUPPLIERS OF TRAINING

The following organisations are involved in training and education:

- The Chamber of Mines (Coal Mining Section), mainly through the training material they supply. It was generally felt that this training material was dated and that the latest processes and technologies should be made available to the mines on video.
- The unions who constantly evaluated the training requirements of their members and how employees met these requirements
- The National Occupational and Safety Association for South Africa (Nosa) through training material and programmes
- CTC College for the training of learner miners in Witbank
- One mining group, INGWE, developed a facility for rock mechanics strata control training (their services are available to other mines and CTC College) at their facilities at the Transvaal Navigational College.

The INGWE Training Centre is known for its advanced training in rock mechanics strata control. The Centre is noted for a life-size simulated underground section and several models are used to illustrate the basics of rock mechanics and how support systems work. This Training Centre provides training to different levels of underground workers, firstly to employees within the INGWE group, but to employees from other mines as well.

The following are valuable characteristics of the INGWE Training Centre:

- The training is aimed at three different job levels: Shift bosses/overseers, miners/section artisans, and section team leaders/operators/instructors.
- It highlights correct methods and procedures.
- It links theory with practice.
- Real-life demonstrations allow miners to experience dangerous practices in safe conditions.
- The models provide clear explanations of abstract rock mechanics concepts.
- The models illustrate both correct and wrong practices.
- Lower-level workers are trained in English and Zulu.

The suppliers of machinery provide important inputs for the training of machine operators. One mine reported difficulties in getting updated training material for the machinery they use, especially in connection with video training packages.

The training divisions of mines were mainly responsible for induction training and refresher training. Separate safety training courses were provided on an ongoing basis.

2.3.3 TRAINING PROBLEMS IN GENERAL

The problems that were mentioned most frequently were lack of a common language and illiteracy, and supervisors who were reluctant to free employees for training. Two reasons were given for their reluctance:

- It caused production losses
- The training departments had little credibility underground. It was mentioned that these departments tended to produce statistics of employees who were trained or not trained.

On the other hand employees themselves complained about the lack of training, the contents of courses, and the way training was presented. The following may be said about the training material:

- Too much information was given in too short a space of time.
- The material was not presented in a way that ensured retention.
- Visual training material was only made available to literate employees and was not packaged in a trainee-friendly manner.
- The Codes of Practice and Procedures manuals were not properly presented as training courses but as manuals.
- The learning style of the majority of employees was not taken into account.
- Most of the training was theoretical and classroom-oriented. Training should involve employees and simulate real-life situations.
- Insufficient refresher material was available to remind employees of what they have learned.

Another important observation was that the section responsible for safety training and the one responsible for functional training were always located in two different departments. This created the impression that safety was one thing and operational training another. It would not only be more cost-effective to combine these departments, but would also improve the quality of the training that is provided.

The training departments complained that they had insufficient staff to fulfil their responsibilities, especially in view of the new mining safety legislation. An example is the mandatory regular testing of all operators, which some claim they cannot manage with current resources.

2.3.4 BASIC TRAINING

The basic programmes presented in coal mines may be categorised as follows:

- Induction training for all new employees - skilled and non-skilled
- Functional training for different underground tasks
- Basic adult education.

2.3.4.1 INDUCTION TRAINING

The basics of safe conduct in preventing roof and sidewall accidents are covered at most mines during induction training, but in varying detail. Most mines make use of the training videos on roof and sidewall safety produced by the Chamber of Mines. These training videos emphasise the rudimentary principles of safety, but are not complete training programmes. Moreover, they were produced a considerable time ago. The underground workers who were interviewed remembered these videos during training sessions and thought they were useful. However, at some mines the videos were just shown and not discussed. Consequently the true value of the video is lost.

Induction programmes at the mines comprise the following:

- Mine and hostel rules and regulations
- Hazard identification and safety awareness
- Standard work procedures and codes of practice
- First aid
- Use of safety equipment.

The testing of employees who undergo induction training varies from mine to mine. In some cases there is no formal testing, but most use written tests for literate trainees and verbal tests for illiterates, signed by both the instructor and the trainee, and testing through demonstration. At one mine a modular testing approach forms the basis for training - if a worker passes the test at the start of the training session, he need not undergo the full training programme.

After induction new workers at most mines are placed in a "pool gang" at the lowest level, starting off as general workers. They will only be given a machine to operate or given a specific task after training and testing.

Workers returning from annual leave undergo training similar to the induction training for new employees, but in most cases it is shortened and viewed as a refresher course to update workers for new developments and changes to safety standards and regulations.

The understanding and definition of different concepts seemed to be a problem. For instance significant differences were found in interpretations of "safe areas", referring to the last row of support. Some miners said it was one metre into the unsupported area beyond the last supported row, and others said it was only safe up to the last row of support. This stressed the importance of a centralised training programme.

Some of the mines actively strive to create a learning culture by:

- Stopping the shift half-way through to discuss safety for five minutes. They identify potentially dangerous situations and decide as a group what should be done about them. Accident analysis indicated that most accidents occur halfway through shifts and they believe a break would focus the workers' attention on safety.

- All accidents (fatal and very serious ones) are studied in a team context to establish the reasons for the accident and how to prevent it. Case studies are written and distributed among the mines so that they can learn from one another.

- In some cases near accidents are also reported and analysed, and this provides a good opportunity for learning and problem-solving.

2.3.4.2 FUNCTIONAL TRAINING

During the functional training course the following were attended to:

- Correct measurement of the mining area to maintain the centreline, placement of roof bolts, etc.
- Correct cutting of the roof is necessary to prevent brows, to ensure an even roof surface, no cutting into shale, etc.
- Working straight, keeping pillar sizes as planned when working with continuous miners
- Correct drilling for conventional blasting to ensure the roof and pillars are correctly shaped, within the required safety grading, etc.
- Correct installation of roof bolts (position, depth, distance from one another, tension, resin spinning, etc.). A very important issue is the timely installation of roof bolts after mining to ensure that cracks do not develop or air seep in.
- Correct inspection of roofs and sidewalls
- Correct sequence of activities (figure 8 approach for conventional mining).

At most mines the functional training of underground workers comprise theoretical input at the training centre, followed by one-to-one underground instruction by the trainer. This training is reinforced on an ad hoc basis by the miner/supervisor who sees it as on-the-job training. However, this assistance was seldom available due to pressure of time. At the end of the training programme (varied in length from mine to mine) trainees are tested by the training instructor and the responsible engineer, managers and supervisors. Testing in most cases was based on going through the inspection checklist and requesting the trainee to operate the machine. The test seemed very superficial and not at all structured.

The training did not seem to be effective in the sense that different operators indicated that they must act different in the same situation. Some machine operators for instance thought they had to stay under the canopy and others said they had to get out and get away if the machine broke down or if a roof fell.

2.3.4.3 BASIC COMPETENCIES

The following list of competencies of the "safe worker" was identified during interviews with a variety of mine employees (note that this was not a thorough competency model-building exercise but just a brief study and that an in-depth study is required for an accurate picture of all the underground posts):

- Physical health
- Observing skills
- Investigating skills
- Teamwork
- Safety knowledge
- Rock mechanics knowledge.

The competencies of machine operators were also identified:

- Physical health
- Coordination
- Dexterity

- Quick reactions
- Estimation skill
- Equipment knowledge
- Basic rock mechanics knowledge.

2.3.4.4 ADULT BASIC EDUCATION

Adult basic education was found to be standard at mines. The motivation was always to improve the quality of the work life of employees, but few employees seemed to benefit from it, for the following reasons:

- Lack of a common language
- Employees had to attend classes after hours when they were tired and could not concentrate.

Many employees and supervisors believed that Fanagalo bridged a gap between workers with different ethnic languages and other European languages. Some thought it would have been better if the mining industry invested in the development and refining of Fanagalo. Now it was discredited and nothing was put in its place.

2.3.5 TRAINING OF SAFETY REPRESENTATIVES

The safety representative should play a key role in creating a safe working environment. However, they do not because of the way they are:

- Selected and their position in the organisation
- Prepared for their role in the safety network.

2.3.5.1 SELECTION AND POSITION

The safety representatives are democratically elected from the ranks of union members at all the mines. Their literacy level is very low, however, which effectively limits their task and they do not have credibility among the other workers. They have no line authority and only serve in an advisory capacity. They can lodge complaints with management and the safety department. Moreover, they have another job to do and cannot pay all their attention to the safety of employees.

2.3.5.2 PREPARATION FOR THE POSITION

Most of the safety representatives received no training for this position. The safety representatives felt they should receive specialised training in the identification of potential hazards. At the moment they are responsible for the safety of other employees while they have exactly the same basic knowledge to prevent mine accidents.

Mines that do provide training cover one or more of the following issues:

- Legal aspects
- Strata control
- Mine standards
- Nosa training courses.

The one training course that accommodated the needs of safety representatives was presented over three days. It was supported by an on-the-job training course presented by training instructors.

Safety officers, who frequently dealt with safety representatives, suggested that more attention should be paid to interpersonal skills training, especially assertiveness skills.

A major problem with regard to safety representatives was that no job description existed for them. It is strongly believed that this would only be a valuable position if it was a full-time position. The following requirements were identified for safety representatives:

- Capable of working with people
- Knowledge about the processes
- Knowledge about the geological characteristics of the mine
- Knowledge about the functioning of the safety structure.

The safety representatives want to be able to make this a career with specific career plans to follow. If there had been a future for them in performing better and in increasing their skills and knowledge in the area of safety, they would have been more motivated - and the other workers would have respected them.

2.3.5.3 COMPETENCIES TO BE DEVELOPED

In addition to the basic competencies, the following also seemed important:

- Assertiveness
- Motivating
- Evaluating
- Rock mechanics knowledge
- Reporting skills
- Hazard identification skills.

2.3.6 FIRST-LINE MANAGEMENT AND SUPERVISOR TRAINING

Although these employees have attended basic training courses there seemed to be a severe shortage of continuous learning. Employees who were promoted to these positions were selected on technical performance. The fact that their attitudes to safety and their interpersonal skills were not taken into account or developed through training, contributed significantly to the lack of discipline in applying safe work practices.

The situation was aggravated because the available training programmes were not used due to production pressure. First-line managers and supervisors indicated a need for training but they did not allow themselves time to attend training courses.

2.3.6.1 COMPETENCIES OF FIRST-LINE MANAGERS AND SUPERVISORS

The following competencies should be developed in addition to the operational and safety training:

- Disciplining skill
- Controlling skill
- Assertiveness
- On-the-job training skill
- Communication skill
- Team management skill

- Observing skill
- Listening skill
- Organising skill
- Knowledge of safety aspects and strata control/rock mechanics
- Knowledge of all work processes and operation of all machines.

2.3.7 MULTISKILLING AND SELF-MANAGEMENT TEAMS

The multiskilling or multitasking approach to organising underground employees is becoming more apparent. Training officers claim that the multiskilling approach has several benefits:

- More career possibilities
- Greater flexibility
- Better understanding for each team member's contribution
- Optimal utilisation of available manpower.

Several other methods are also implemented to ensure that employees are optimally used:

- A multi-operator system to enable all operators to operate a least three machines
- Self-managing teams by removing the team leader.

However, mine managements were not necessarily impressed by these changes. They felt that managers had more decisions to make than before as a result of flatter organisational structures, smaller work teams and multiskilling. Job contents have been changed and include more general tasks than before, so that not enough time is available for essential basic duties, especially safety-related checking of the work of subordinates.

It was stated that smaller work teams suffered under production pressure. Basic tasks that should have been done were left undone as not enough employees were available to do the job. Underground workers stated that they were being pushed to the limit. Good examples are not barring the faces because there were not enough people available to do barring work. It was also very difficult to release workers for training. Not enough backup staff were available to stand in, so that the other team members had to handle the extra tasks. If one team member was taken away, one machine would be left standing. This was something multiskilling would address.

2.4 COMMUNICATION ON SAFETY AND HAZARDS IN SOUTH AFRICAN COAL MINES

2.4.1 INTRODUCTION

It was originally intended to have the communication officer or the person who is responsible for managing communication at a mine explain their work. However, none of the mines employed a person who was dedicated to ensuring effective and efficient information flow. Nevertheless all the mines tried to ensure that employees remained aware of safety issues. Several problems were identified because nobody coordinated the mines' efforts at communication.

2.4.2 THE COMMUNICATION CLIMATE

On the one hand employees appeared to be very open towards each other due to their dependence on each other and because of a common enemy - dangerous conditions. However, it became evident during the interviews that there was a severe lack of trust between different work groups and different job levels.

Operational employees felt that management did not care about them. They cited several incidents when they requested repairs or indicated hazardous situations when nobody reacted. They were for instance still using a continuous miner without a canopy despite several requests.

The supervisory staff did not trust the operational staff because they believed that the operational staff did not heed their warnings. The supervisors kept warning them about potential dangers but it made no difference - they still got killed or injured.

The fact that there was no common language contributed to the mistrust. A severe lack of understanding existed because employees did not share the same language. Groups consequently formed - the different ethnic languages and the European languages - and these groups again subdivided into smaller groups. The situation was not at all conducive to creating a safe working environment.

The autocratic management style of mine managements was not well received. This led to the formation of even more groups - miners who included all underground staff, against management who included the surface employees. However, the managements believed that they were participative, but that somebody had to make decisions. They also felt that the inadequate safety discipline and lack of commitment to training could only be addressed by means of an autocratic style. They nevertheless believed that they were participative with regard to other issues.

2.4.3 COMMUNICATION NETWORK

The organisational structure provided the basis for all communication networks in mines. Briefing groups, team discussions and green areas were often mentioned. A primary feature of these networks was the top-down nature of the messages. There did not seem to be any way to report incidents and especially potential dangers except to the supervisor. If the problem was not addressed, employees felt they had nowhere to go.

At one mine this problem was identified and overcome by means of a 24-hour hot line so that employees could report incidents or hazardous conditions - anonymously if they wanted to.

- The safety representatives were not vital links in the communication network as they should be. This was due to the following reasons:

- Safety representatives had no line authority and were only used in an advisory capacity. Someone said they had no teeth or authority, and that they could not overrule the shift boss. They could, however, lodge complaints with management.
- They were not formally trained and lacked certain basic competencies in communicating unsafe behaviour and conditions to colleagues.
- There was insufficient interaction between safety representatives and safety officers. The safety representatives felt intimidated when they had to report matters to the safety officers.
- The safety representatives were not trusted by employees because they were not able to do their job of hazard identification properly.

- Safety representatives reported unsafe behaviour or conditions to the face boss, verbally and not in writing. Therefore they had no proof that they had reported a dangerous situation. Neither was there any pressure on others to act because nothing had been written down.
- The lack of contact between shifts caused a breakdown in the information flow in the network. Despite the fact that a written report was left behind, employees felt that more verbal contact was required to explain conditions.

The communication network did not function effectively due to the following:

- Safety officers had to play a more crucial role in the network but they seemed to focus more on geological issues than on human issues. The fact that most of them tended to keep to their checklists meant that other important issues went unnoticed.

- The unions do not play an effective role in safety communication. Safety did not seem to be a key issue for them. The workers accused them of being uninformed about hazard identification and creating a safe working environment. Management, on the other hand, accused them of distorting safety information for their own benefit. The problem seemed to be a lack of training regarding their role in the communication network and insufficient communication skills.

  Information meetings before shifts seemed to play an important role in creating a safety climate, but is not effective. The problem is that these meetings were not connected to a communication network. These meetings were like islands with no learning or communication from one to the other. Suggestions and concerns tended to stay within the meeting. Feedback on issues raised at these meetings was scarce.

  The workers were also not very impressed with the information meetings or any other safety meeting. The found them repetitive and they thought they had enough "pep talks and posters" on safety. They wanted action to ensure a safer workplace.

  The half-way breaks in shifts are seen in the same light - too repetitive. Some employees were very open and said that they would rather sleep than listen to the same issues repeatedly. However, these are valuable meetings and important issues are discussed:

  - Did they experience any dangerous situations since the start of the shift?
  - Were there any tools or equipment which they perceived as dangerous?
  - Have they seen an employee who was doing something dangerous?
  - What can they as individuals do to create a safe workplace for the rest of the shift?

  Safety forums and safety days were perceived as more effective. At one the workers were involved in developing standards and at the other they received recognition for safe behaviour. Care should be taken however not to have these become monotonous as well.

  The safety meetings held by the safety representatives were viewed with scepticism. Employees doubted if these meetings could mean much if the representatives were not considered effective underground. Management believed these meetings were important but the representatives had to be trained in meeting procedure and in implementing the decisions made at these meetings.

2.4.4 ACCIDENTS AS MESSAGES

It might sound strange, but information about accidents and near accidents should be utilised as key messages with a view to learning something in a mining environment.

It was found that the way in which accidents were documented and reported was not only unique to every mine, but was in most cases very superficial and incomplete. Most mines did not seem to realise that the information should be communicated so that employees could learn from it.

The fear was often expressed that workers were reluctant to inform their supervisors of near accidents because the information would be used against them. Due to this lack of courage many learning opportunities are lost. If a better recording system existed these mistakes could still be reported and the person could stay anonymous.

2.4.5 COMMUNICATION METHODS

Various methods are used to communicate unsafe areas and safe behaviour to workers.

2.4.5.1 UNSAFE AREAS

Various techniques are used for visual communication of dangerous areas to workers:

- Reflective tape/chevrons from the last row of roof bolts indicate the last line of supported roof. Another advantage of this technique is that it indicates the ventilation status
- Red material hanging from the last row of roof bolts
- Wire/mesh with STOP/ENTRY FORBIDDEN signs combined with chevron tape to mark off dangerous areas
- A person to guard unsafe areas.

Although widely used, the opinion was expressed that using chevrons are problematical in terms of effectiveness:

- At one mine, for example, the EIMCO driver unknowingly drove through the chevron tape at the start of a shift and did not replaced it afterwards, creating a very unsafe workplace.
- At other mines it was applied haphazardly.
- Misuse of danger/chevron tape was mentioned. Chevron would for example be used to indicate the location of the oil store, in order to make it look smart. This could lead to a situation where the workers cannot discriminate between chevron tape indicating danger and tape indicating something else.
- Some employees thought that using danger tape on its own is insufficient because employees sometimes remove it. Other workers are consequently not warned.
- Some employees just ignore chevron tapes. This happened during one of the mine visits. Workers in the underground waiting area ignored the chevron tape, jumped over it and sat down to rest in an unsafe area.

2.4.5.2 COMMUNICATION ON SAFE BEHAVIOUR

Several group methods have been mentioned on sharing safety communications with employees. Other ways of doing so will now be discussed.

- Notice boards, in combination with posters, were the medium most used to bring safety issues to the attention of employees. In addition to the posters, the notice boards also displayed safety statistics and reports. Most of these notice boards also provided other information as the boards were placed in the meeting areas. Unfortunately the boards were not properly maintained and therefore lost their communication value.
- Posters were effectively used in mines to keep employees aware of safe behaviour. The workers appreciated this and perceived it in a positive light.

A number of aspects still have to be attended to:

- The generic nature of the posters and the fact that they did not specifically refer to roof and sidewall accidents
- The outdatedness of the posters, depicting technology and situations that are no longer relevant in coal mines
- The unattractiveness of the posters - dull colours and unattractive copy and layout
- The fact that only Afrikaans and English are used
- Inadequate maintenance of the posters on display.

Ad hoc news flashes about accidents were used at some mines. These news flashes, in A4 format, are distributed among all employees and on the notice boards. The news consists of a brief description of how, when and where it happened and which employees were involved in the accident, and recommended action to prevent similar accidents in future.

Despite the fact that the idea was good and that it drew the attention of the workers to accidents, it cannot be effective on its own. The copy was not presented in a user-friendly manner, especially for semi and newly literate employees. Nor was the information made available in the ethnic languages. If these messages had been discussed with the workers in their work groups the results would have been more positive.

Newsletters were another communication medium often used at mines. Most covered the safety issue but in a very superficial manner. The presentation of these publications was generally unattractive and there was some concern about their readership.

The articles on safety gave one the impression that the subject was only covered because it had to be, not because of any enthusiasm about it.

The lack of information in the ethnic languages and easy-to-read reports made the publications - which could play an important role - virtually worthless to the majority of employees.

2.4.6 IN CONCLUSION

What the central nervous system is to the body, the communication network ought to be to the organisation. The communication network and the supporting media are not effective and contribute significantly to the lack of discipline in connection with safe conduct.

2.5 SAFETY STANDARDS AND PRACTICES

2.5.1 INTRODUCTION

Throughout the standards section of the project the NPI endeavoured to concentrate on the following aspects:

- Codes of practice (COPs)
  - Validity
  - Contents
  - Interpretation
- Major role players using the COP
- Analysis and evaluation of safety practices
  - Hazard identification
  - Adequacy of support
  - Quality of inspections
  - Adequacy of barring
- Lighting of the coal front
- Reporting and follow-up practices.

The following aspects are not addressed in this report:

- **Longwall mining**

  As known to most, the method of support used at the coal front in longwall mining differs completely from board and pillar-mining. However, the rest of the mine, i.e. roadways and other means of access to the coal front, has to be made safe in a similar manner for both types of mining. Therefore the findings and recommendations regarding the above-mentioned areas apply in both instances.

- **Pillar extraction (allowing the roof to fall)**

  One of the mines that was visited is currently doing stooping (pillar extraction) by means of mechanical equipment (continuous mining and Voest machines). This particular mine is the only one with unique, dangerous sidewall and rib-side rock formation conditions due to horizontal layers of coal and shale. A lot of roof caving also takes place.

The NPI team concluded that the only way to support the pillars (rib side) of this particular mine was to cast a concrete wall around the pillars. Unfortunately the country is running short of the particular quality of coal mined here and therefore stooping is required.

The NPI team observed roof caving in this mine to a height of ± 7 m. Due to the poor geological conditions the mine spends much more than other mines on supporting the roofs and sidewalls. As a matter of fact, it is one of only two mines in the sample who have to support the pillar sidewalls (rib side) using roof bolts, and dowel pins combined with headboards, meshing, lacing and fishnets.

In spite of all the problems, this mine has maintained a fairly good accident record over the past three years although it had an accident with two fatalities during 1995.

- **Accident statistics**

  Accidents referred to in this section of the report only include nine accidents (see Appendix 1). These accidents occurred during the past 18 months and the NPI could obtain reliable reports on these accidents as well as personal evidence from observers.

2.5.2 LEGAL VALIDITY OF CODES OF PRACTICE (COP)

2.5.2.1 LEGAL DOCUMENTS

All the companies that were visited presented the NPI with COP documents. These documents contained all the relevant technical details regarding safety procedures and safety standards. The documents were all duly stamped and signed by management and by the legal government official who represents the government mining engineer.

The names and titles of the mining officials who served on the standards committee at the time are all on record.

In only two cases the COPs were dated 1992 and earlier. In one of these cases the NPI was presented with a document containing amendments under a later date.

The NPI concluded that the mines that were visited had followed the legal instructions regarding the setting of standards, describing procedures and documenting the relevant data in order to avoid roof and sidewall accidents.

2.5.2.2 PARTICIPATION IN PREPARING COPs

The following is a typical example of the officials who serve on a standards committee:

- The mine manager
- The manager mining
- The planning manager
- The technical manager
- The safety officer
- A rock engineer.

This composition is approved by the regional director of the Department of Mineral and Energy Affairs.

In some instances mine overseers and/or geologists and/or surveyors were included in the standards committee. (Rock engineers are also referred to as rock mechanics engineers or geotechnical engineers.)

2.5.2.3 KNOWLEDGE USED IN PREPARING COP DOCUMENTS

The survey revealed that the technical knowledge (data) used in preparing the COPs is obtained as follows:

- Geotechnical information obtained from the drilling of exploration holes when the mine was started. In a few instances additional holes were drilled afterwards to explore new reserves in areas where conditions were unknown.

- Specialised knowledge of the rock engineering discipline supplied by the rock engineer. The NPI concluded that the academic standard of the rock engineers employed by the mines is high. (More is said in Section 5 about the presence of this discipline at the mines.)
- Historical knowledge of the behaviour of underground strata at the particular mine and other mines supplied by the line functionaries, i.e. mining personnel, geologists and surveyors.

The NPI cannot criticise the soundness of the knowledge and inputs used in preparing the COPs and which address strata behaviour across a mine. However, when abnormal and unpredictable strata behaviour is dealt with on a daily basis, the picture changes. More is said about this later in the report.

2.5.3 CONTENTS OF THE COPs

2.5.3.1 CLARITY

- **Descriptions**

  There was not a single case of unclear descriptions of the support to use, where to use it, how much to use and which procedures to follow. In some instances the descriptions regarding the support of cracks, slips, brows and alongside dykes were more comprehensive than in others.

  The NPI concluded that nobody working underground could say that the mine's COP does not address all issues regarding roof and sidewall support that are normally encountered in mining for coal underground.

- **Illustrations**

  All the COP documents contain sketches and illustrations, showing the location of temporary and permanent support relative to the face, intersections, centrelines, brows, slips, cracks and dykes. The sketches and descriptions clearly indicate the density of the support (number of roof bolts), spacing dimensions, length of roof bolts, types of roof bolts and methods of installation.

  The COPs also provide guidance about where headboards and/or W-straps could and should be used.

2.5.3.2 SIMPLICITY OF COP CONTENTS

The effectiveness of a COP is directly linked to the intensity of its application underground. The intensity is again linked to factors such as comprehension, awareness and motivation. This section of the survey was concerned with how well the contents are understood, right down to the lowest ranks of the organisation's workforce.

To give a written document (COP) to a team leader, a continuous-miner driver, a duff-lashing operator, etc., will be fruitless. They do not understand the written instructions and some are even illiterate. It is therefore clear that the contents of the COP must be understood and verbally conveyed to the workforce by someone higher in the hierarchical line. This person is the miner, also ranked as a face boss, the shift overseer or even the mine overseer (mine captain).

Exactly this is being done and the NPI can give the assurance that these tutors do understand the written instructions and are doing the necessary training and tutoring.

The question that arises at this stage is why such a big to-do about something that is in place? The NPI agrees, but would like to defend this elaborate discussion with the statement that a person who cannot use the written word, illustrations, etc., only has his memory to refer back to.

It is of paramount importance that the training, explanations and tutoring done at the waiting place, the miner's box or the green area, should be as thorough as possible and should be done before each shift.

This approach is followed by all the mines that were visited. However, during the interviews with the underground workers it became clear that some are getting bored with the "same song every day". This aspect is dealt with in detail in the section of this report that deals with training.

With the exception of three mines, the NPI observed copies of the COP that applies to safety posted in locations where the workforce meets before the shifts commence.

The NPI states that the contents of the COPs are understandable to those who can read and interpret the information, and that it is tutored to those who only understand the spoken word. (Also see the sections dealing with training and communication.)

2.5.4 IDENTIFICATION OF SAFE AND UNSAFE AREAS

2.5.4.1 COP IN HAZARD DETECTION

A COP serves two purposes:

- Firstly it prescribes the minimum precautionary measures to be taken in order to make roofs and sidewalls safe. As stated before, the knowledge applied in formulating the COP is of a general nature and is based on historical data and certain expectations.

- Secondly the COP provides guidelines to the line functionaries, i.e. the face boss, the shift overseer and the mine overseer, on the direction to follow should exposure of the roof and sidewalls reveal conditions other than those normally expected. In such cases, the COPs stipulate that other types of support should be used, that the density should be increased, that the spacing and location should be changed, etc. These decisions are left to the discretion of the responsible person (official). When the COP does not prescribe 100% systematic support, areas are sometimes declared safe after:

  - Examination and minimum support
  - Examination and no support at all.

The data used in assessing the situation are obtained from visual inspections of the roof and sidewalls and by using a sounding stick. (Use of the sounding stick is discussed in more detail in Section 6.)

The above modus operandi in making on-the-spot decisions about whether an area is safe or what should be done to make it safe, takes place daily. The NPI has serious doubts whether the available data enable the officials to come to a sound decision every time.

2.5.4.2 UNSAFE AREA - WHAT TO DO

The NPI observed a few cases where officials decided that an area was unusually unsafe. In these instances the roof and/or sidewall showed visible cracks, slips or other potentially dangerous features. The officials consequently applied absolute maximum safety precautions.

The NPI concluded that there is a tendency to oversupport areas revealing dangerous features. The accident statistics in Appendix 1 contain no entries for accidents which occurred in an "extremely" hazardous area.

These observations led to the conclusion that when adequate data are available, correct decisions are taken.

2.5.4.3 CLASSIFICATION OF CRACKS AND SLIPS

The visible appearance and the differences between cracks and slips were pointed out and explained to the survey team during underground visits. It was explained that a crack, especially in sandstone roofs, could be caused by mineralogical behaviour or by relative movement between layers of stone, the latter indicating slipping between layers that could fall and cause accidents.

Investigations of accidents revealed cases where innocent, harmless cracks were actually slips which eventually caused serious accidents.

The NPI is of the opinion that any crack should be regarded as serious and treated accordingly (see Sections 9 and 10).

2.5.4.4 TIME ELAPSED FROM EXPOSURE TO SUPPORT

It was explained to the NPI that after removal of the coal which creates a new roof, gravity, shocks (vibrations and explosions) and moisture in the air could cause the coal, left over against the roof, to form loose slabs and/or loose humps which could eventually fall. It is therefore essential that roof support be installed as soon as possible after mining. The officials who were interviewed were al fully aware of this requirement but claimed that a shortage of roof-bolting equipment, especially in areas where continuous mining took place, sometimes caused roof-bolt installation to fall behind.

2.5.5 MAJOR ROLE PLAYERS

2.5.5.1 LINE FUNCTIONARIES

The line functionaries, especially those who work underground, are undoubtedly the most important role players in the mine's efforts to work safely. They are the people who have to apply the standards, who initiate, manage and take the actions, do the training and keep awareness on a high level. They are also the people who are exposed to the dangers and are usually the ones who are injured or killed in accidents.

The face boss (miner) is a leading role player underground, together with the shift overseer (shift boss). Between these two officials decisions are taken daily which could literally mean the difference between life and death.

The NPI concluded that the officials are doing fine within the confines of their own shortcomings and the inadequacy/inaccuracy of the data at their disposal. They act within the parameters of the law and are usually the first-line functionaries to be investigated when accidents occur.

Unfortunately the NPI also observed the following:

- Miners and shift bosses are generally inadequately trained in the rock engineering discipline.
- Their knowledge is based on experience, visual inspection and the sound made by the sounding stick. This knowledge is obviously inadequate in the light of the accident statistics in South Africa. More is said later about aids that are available for proper hazard detection.

- Miners and shift bosses form the third line of management in the organisational structure and are therefore directly responsible for everything that happens at the coal face, including achieving production output targets. This aspect puts them under continuous pressure not to waste time but to carry on with the job. Under these circumstances they have to take quick decisions, including decisions regarding safety.

  The above statement does not imply that these officials take shortcuts or chances at ignoring the law as expressed in the COP. As a matter of fact, the survey did not indicate any such malpractice.

  However, taking quick decisions based on inadequate data could produce decisions that contain a degree of inaccuracy, i.e. declaring an unsafe area to be safe or deciding to use only minimum support where more is needed. The study of accidents clearly points in this direction.

- It is not possible always to supervise and manage the supervisory labour force reporting to the miner (face boss). The team leaders, equipment drivers and assistants, and especially the sounding-stick operator, also have to make decisions from time to time and take action on their own initiative. Again inaccurate actions could be taken.

  However, if more and especially more accurate data were available to indicate the condition of the roof and/or sidewalls deeper than the eye could see, decisions and subsequent actions would be more accurate.

2.5.5.2 ROCK MECHANICS ENGINEERING

This discipline, also called rock engineering and geotechnical engineering, is the field of study that determines the physical behaviour of the earth crust. This discipline plays a leading role in determining whether support is needed, and if so, which type of support, which configuration and in what density.

All the mines that were visited made use of the services of rock mechanics engineers, but on a part-time or a consultation basis. Not one of these mines employed a full-time rock mechanics engineer.

The mines which are part of large mining houses make use of a centralised service where an engineer visits a mine at regular intervals and is also available on call. Smaller mines make use of consultants, either private or from the CSIR.

The NPI considers the rock mechanics engineering function the most important technical assistance to the line functionaries in creating a safe roof and sidewall situation underground. This assistance is not only needed in preparing a COP, but should be available whenever required. The NPI is convinced that accidents occur due to inaccurate daily decisions. The current situation does not make provision for such extensive availability of rock mechanics engineering expertise underground.

Not a single accident presented to the NPI was accompanied by a rock mechanics engineering report to explain what caused the accident from a technical point of view.

2.5.5.3 SURVEYOR AND GEOLOGIST

All the mines that were visited employed full-time surveyors and only two mines did not employ a full-time geologist.

It was found that these staff functionaries normally have good, but not adequate, knowledge of the geotechnical aspects of rock behaviour and are always prepared to make their knowledge available to mining personnel.

In a number of instances a geologist was part of the team responsible for drawing up a COP.

Interviews revealed that the geologists and surveyors would like to know more about rock mechanics engineering and are prepared to play a more active role in (and be more responsible for) underground roof and sidewall safety.

2.5.5.4 SAFETY OFFICER AND SAFETY REPRESENTATIVE

- **The safety officer**

  Nobody plays a more active and important role in training and awareness programmes than the safety officers. This function, together with the training department, is responsible for induction training, basic training and follow-up training of all underground personnel. In a number of cases the training has been extended to higher levels in the organisational structure. The NPI found that the training officers are generally enthusiastic about their tasks, they know the legal directives and are among the main interpreters of COPs.

  The safety officer's office is also responsible for:

  - Democratic election procedures to appoint a safety representative for each underground mining team or section
  - Assistance in the investigation of accidents
  - Keeping records of incidents of roof and sidewall collapses (incidence recording) and for advice on avoiding future mishaps.

  An outflow of the safety officer's task was the appointment of the safety tutors found at some mines. These officials mainly move among the underground sections every day for on-the-job tutoring on COP applications and safety practices.

  The safety officer works closely with the miner's training office and is sometimes also the mine's training officer. The exact training methods, the contents of courses and the available training facilities are discussed in the training section of this report.

- **The safety representative**

  The appointment of safety representatives to serve in the underground stope teams is due to trade union action to improve safety aspects in the South African mining industry. Today the appointment of safety representatives has been legalised and the NPI found the following:

  - A safety representative has been appointed in all the stope teams visited underground.
  - The position is not autonomous but is additional to a line function. This means that anybody could be elected and appointed, from a continuous-miner driver to a hand-lasher.
  - The safety representative has no veto right and/or delegated power to give direct instructions. He can give advice, report incidents and at best reprimand fellow workers when they act unsafely. He has the right to report the miner and/or shift boss to higher authority if that would be in the best interests of safety.

  - Not a single safety representative contacted during the study had any additional training over and above the normal (minimum legal requirement) safety representative's training.

In the NPI's opinion one mining group has a commendable, low-level training course in rock mechanics. Not one safety representative interviewed, not even those associated with this group, had attended this particular training.

The NPI would like to interpret and comment on the position of the safety representatives as follows:

- The position satisfies trade unions and employers alike.
- These representatives do not have line authority or a veto right and are therefore still subject to the decisions of the highest line authority underground.
- The safety representative is in a line function and is quite often not in a position to observe and evaluate "other" safety practices, e.g. a continuous-miner driver cum safety representative cannot supervise the activities of the roof-bolt team; it would be physically impossible.
- Safety representatives are not properly trained and only have their experience and basic training to fall back on.

The NPI concluded that the position of the safety representative as it is currently defined does not serve the greater ideal, i.e. to improve safety. It is a toothless appointment filled by somebody who may have neither the knowledge nor the ability to fulfil expectations.

The democratically elected safety representative could be a strong informal leader among his team members, but at the same time an non-intellectual person with very little ambition to improve safety.

However, the NPI is of the opinion that the position may be put to good use.

2.5.6 ANALYSIS OF "MAKE SAFE" PRACTICES AND RESULTS

2.5.6.1 SYNOPSIS

Table 3 presents a summary of the nine accident studies, from reports, by the team during the survey. Only Accidents 2 and 9 may be ascribed to human error. The rest of the accidents occurred in areas that were supposed to be safe in terms of the minimum requirements dictated by law and prescribed in the COPs.

TABLE 3

ACCIDENT SUMMARY

ACCIDENT No.	1	2	3	4	5	6	7	8	9
Cut, drill, blast				✓	✓				
Mining	✓	✓	✓			✓	✓		✓
Voest Mining								✓	
Systematic support		✓	✓		✓	✓	✓	✓	
Non-systematic support	✓			✓					✓
Declared safe area	✓			✓					
Unsupported area		✓		✓					
Supported area			✓		✓	✓	✓	✓	✓
Forbidden area		✓							✓
Roof (hanging wall)	✓	✓	✓	✓	✓	✓	✓		✓
Sidewall (rib side)								✓	
Fatal	✓		✓	✓	✓	✓	✓	✓	✓
Non-fatal		✓							

Accidents 1 and 4 occurred in mines (areas) that did not prescribe systematic support, but the locations of the accidents had been examined and declared safe.

Therefore five out of seven accidents happened in areas that were supported and that were to all intents and purposes safe areas.

These statistics, which are supported by other studies and surveys, indicate that a "safe" area is suspect even if all the legal requirements have been complied with.

2.5.6.2 HAZARD RECOGNITION AND IDENTIFICATION

The studies and statistics of accidents clearly indicate that roof and sidewall hazard recognition and identification are at their best only partially reliable. If all hazards were recognised and identified, and if maximum (if a maximum exists) precautionary measures were taken, the number of roofs and sidewalls collapsing on people would drop to an absolute minimum - would almost disappear.

Only the following recognition techniques are currently used:

- Visual inspections. Roofs and sidewalls are simply looked at before conclusions are drawn regarding cracks, slips, brows and loose pieces of coal and/or rock. This could almost be obvious. A hazard that reveals itself is identified and the necessary steps are taken, i.e. it is supported, it is barred down and supported, it is only barred down, or it is identified as unsafe and the area is declared forbidden.
- The sounding stick. The only technique currently in use to recognise a hidden hazard is to hit the roof with a round wooden pole with a copper cap at the front end. The sound made by the roof surface is then interpreted as either solid or having layers that have parted along a horizontal plane.

Again the obvious is evident. If the roof has parted and the partitioning is wide enough (how wide is unknown) and the parting is not higher/deeper than ± 300 mm from the visible surface, a distinct hollow (drumming) sound will reveal a parting and thus indicate a hazard. Precautionary actions then follow which could include barring down, installing roof bolts or a combination of these.

The techniques are indeed suspect. During interviews mining managers and other employees agreed that the techniques/methodologies are not adequate, but in the absence of anything better they have to make the best of the situation.

2.5.6.3 NEED FOR AND ADEQUACY OF SUPPORT

- **Temporary support**

  The need for temporary support, especially during the period after exposure of the roof and before the installation of permanent support, is of vital importance.

  The NPI has found that all the mines are very aware of the need for temporary support while roof bolts are installed for permanent support. Three types of temporary support are used, i.e. wooden poles, mechanical jacks and hydraulic jacks mounted on roof-bolt cars.

  The use and adequacy of temporary support could not be criticised. The accident survey during the project revealed only one roof fall in the vicinity of a roof-bolt car. However, the victim moved away from the temporary support area and was hit by a fall of ground.

- **Permanent support**

  There could be no argument against the need for permanent support. It is still the only known way of increasing the safety factor in respect of roof falls and in some instances the scaling of sidewalls (rib sides).

  The statistics show that the majority of accidents occur in areas that have been supported. The roof caves between the roof bolts and in some cases the roof bolts fall out as well. This observation leads to the following conclusions:

  - The amount of support and the density of roof bolts are inadequate.
  - Some accidents could have been avoided if longer roof bolts had been used.

  These conclusions are not based on the statistics only. It was quite evident that poor roof conditions or conditions perceived to be hazardous could be counteracted as follows:

  - Increasing the number of roof bolts in an area and reducing the spacing between the roof bolts
  - Using headboards in order to increase the area of contact with the roof
  - Using W-straps to increase the area of contact
  - Using longer roof bolts and in some cases using roof cables of up to 3 m in length and longer
  - Changing from mechanical roof bolts to full resin-secured bolts.

  All the above precautions were observed when a roof was evidently hazardous or when an accident occurred.

  One cannot help asking the question: If the adequacy of permanent support could be increased by doing all or some of the above, why can't the adequacy in general be improved substantially? Is it a situation of the obvious is evident and for the rest we hope for the best?

- **Quality of inspections**

  The number and frequency of inspections could not be criticised. Inspections are carried out strictly according to COP directives. However, the quality of the inspections is suspect due to the inadequacy of the available techniques for proper hazard recognition.

- **Adequacy of barring**

  During the underground visits the survey team members concentrated on spotting areas against the roofs and sidewalls that required barring down. The frequency of this requirement was quite high, especially against rib sides regarded as conditionally good.

  When pointed out to the mining personnel, immediate action was taken and in most cases it was admitted that the area needed barring down.

  Barring down immediately after exposure, during inspections, takes place according to COP stipulations.

  The NPI concluded that the barring down of older areas is somewhat neglected. One fatal injury could be ascribed to inadequate barring down of a rib side.

2.5.7 LIGHTING OF THE COAL FRONT

When modern mining equipment such as continuous-mining machines and Voest machines are used, the driver is expected to observe the roof while advancing and to detect any visible hazards such as cracks or slips. In certain mines the driver is expected to stop his activities and withdraw his machine when such hazards are observed. The exposed roof then has to be examined and made safe before cutting continues.

The NPI concluded that this task is almost impossible due to the coal dust and the inadequacy of the lighting at the front. One is hardly able to see the roof let alone spot a crack unless it is of rather unusual proportions.

When mining a channel between pillars the driver operates against a dead end, leaving only the side of entry open for the coal dust to escape. This could be compared to someone trying to blow smoke into a bottle. The more smoke that is blown in, the more escapes backwards. The available lighting at the coal front is confined to the lights mounted on the machine, the lenses of which are normally covered with a layer of dust, and the head lamps of the driver and his assistant.

It was observed that certain mines use high-speed jet fans to try to blow the dust out of the area that is being mined. It was not very effective because the air does not move along a U-shaped trajectory. The result is a whirlwind effect, causing the coal dust to circulate so that lighting becomes even more difficult.

2.5.8 REPORTING AND FOLLOWING UP INCIDENTS

One gets the impression that the majority of mines do not regard rock-fall incidents resulting in near misses or non-fatal accidents as serious. This conclusion is based on the following:

- Only two mines were keeping a record of incidents and near misses. These incidents were recorded but not followed up.

- Three of the mines that were visited could supply the NPI with records of non-fatal accidents caused by ground falls. Not one of these mines could offer proof that these accidents had been followed up by means of proper reporting on the root causes of the accidents. Reports such as "while installing a roof bolt a piece of coal fell on the head of the roof-bolt operator; he suffered concussion", were found in a number of cases. No information regarding temporary support, the adequacy of the preceding inspection or other safety factors is supplied. On the other hand, when a fatal accident takes place, the investigations seem to be never-ending.

  The expression, "look after the smaller accidents and incidents and the major ones will look after themselves", apparently does not apply to the mines the NPI visited.

3. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are based on the findings discussed in Section 2:

3.1 REASONS WHY EMPLOYEES IGNORE UNSUPPORTED, UNSAFE ROOFS AND SIDEWALLS

The project team came to the conclusion that there were a few key reasons why employees go under unsafe roofs and ignored unsupported sidewalls and that this problem could be addressed in a number of ways.

3.1.1 MINE REWARD SYSTEMS FOCUS ON PRODUCTION, NOT SAFETY

Attempts should be made on the industry level to ensure a balance between production and safety. Stakeholders in the mines should form a forum to develop ways and means that would ensure a profitable enterprise where employees could feel safe.

3.1.2 EMPLOYEE COMPLACENCY IS NOT COUNTERACTED

Employees should be made aware of the dangers surrounding them without scaring them so much that they can no longer perform excellently. Employees should be told of accidents in other mines and why these accidents occurred. However, this would only be possible if a proper, centralised recording system was available.

3.1.3 NO COMMON LANGUAGE

As long as employees do not understand instructions, they will not be able to heed warnings and the mistrust between groups will remain.

The mining industry should seriously consider the feasibility of reinstating, developing and refining an operational language similar to Fanagalo. The shortcomings of Fanagalo should be investigated and excluded from this operational language. It should be made compulsory for every employee, from the mine manager to the lowest operational employee, to attain a certain level of competence in this language.

3.1.4 INEFFECTIVE COMMUNICATION ON SAFETY AND HAZARDS

The communication network should be based on the structure of the mine. Key communicators and communication skills should be identified, in relation to the roles and responsibilities of the different role players in the safety structure. These key communicators, who should be supervisors, safety officers and safety representatives, should be authorised to take steps, within specified limits, against employees who behave unsafely. Regular forum meetings should be held to discuss problems and opportunities. These key communicators should view themselves as a team with the objective to reduce accidents, and in particular roof and sidewall accidents.

3.1.5 OUTDATED TRAINING METHODS AND MATERIALS

The information age and the emancipation of employees had a considerable impact on training requirements. New training material should be developed in a participative manner. Representatives of labour, the engineers, management and training professionals should be involved. All training materials should be related to the machinery and skills that are currently used.

Creative ways have to be identified to ensure continuous learning (see 2.1.4.3 for more details).

3.1.6 INEFFECTIVE UNDERGROUND SAFETY STRUCTURE

The relationship between the safety representative and the safety officer has to be clarified. The roles and responsibilities of the two positions should be documented and communicated to all the employees. The employees who are selected to fill these positions should receive training in the competencies that would be required to ensure safety.

3.1.7 THE ROLE OF SAFETY REPRESENTATIVES

The current job description of the safety representative serves no purpose at all. Nothing in respect of safety will change if the post is done away with.

The NPI recommends the following in this regard:

- Give the position autonomous status.
- Delegate more authority to the position, even to the extent of giving the safety representative a veto right to stop activities for safety reasons if deemed necessary.
- Only appoint well-trained, experienced candidates with an appropriate educational background in this position.
- A candidate who is selected by the team should first pass scrutiny, based on the above and other prerequisites, before he is appointed and trained.
- Only candidates with a proven track record of reliability, honesty and enthusiasm, with the right temperament and personality, should be appointed to the position of safety representative.

3.1.8 THE SUPPORT PHILOSOPHY DOES NOT CREATE A SAFE WORKING ENVIRONMENT

SYSTEMATIC SUPPORT OR NOT

At the moment the law allows the COP advisory committee to determine the general support philosophy at each mine. The committee decides whether the mine requires 100% systematic support, systematic support only where needed, or non-systematic support, with the option to move to minimum support and/or systematic support.

As evidence of a change in the mine management culture the NPI recommends that serious consideration is given to the current practice of systematic support. Whilst recognising the amount of research already carried out and the international debate relating to the extension of systematic support practices, the project team needs to state the obvious: more roof and wall support in accurately designated danger areas reduces the consequence of roof and wall collapse.

The NPI recommends the following changes to the support philosophy:

- All sections of a mine should consider substantially increasing systematic support.
- Consideration for additional support, such as meshing, lacing, w-straps, etc., in high-risk areas should be given.

- If necessary, this approach should be enforced by law.

- Any deviation from systematic support to a lesser support policy should be approved in writing, after investigation, by the regional director of the Department of Mineral and Energy Affairs.

- No mining official will have the authority, delegated or otherwise, to deviate from the norm, i.e. systematic support.

- More roof bolts (higher density) should be used to counteract the current (high frequency) occurrence of roof falls between supports. If feasible, a minimum density should be stipulated by law.

- Roof falls that occur where the roof bolts have fallen out could have been prevented by using longer roof bolts. If feasible, minimum specifications should be enforced by law.

- The mining industry should seriously consider using headboards and/or w-straps more often. Headboards and/or w-straps should be used at the slightest indication that the roof is more fragmented than expected, irrespective of whether sections "look" good or not.

3.1.9 INADEQUATE LIGHTING OF COAL FACE

Something should be done to make the coal face and newly exposed roof and sidewalls visible during mining operations. This aspect requires further investigation and should not be unduly delayed.

3.1.10 PERIOD BETWEEN EXPOSURE AND SUPPORT TOO LONG

Roof support activities should never fall behind and maximum periods between exposure and support installation should be specified in the COPs.

3.1.11 MAINTAINING PROPER COMMUNICATION METHODS

Mine managements should ensure that all the communication methods are current, properly used and serving their intended purpose. Safety meetings, when and whatever the format, should not be repetitive, warning signs should be kept clean and visible, chevron tape and other warning materials and boards should be properly maintained and should never be used for other purposes.

3.1.12 CENTRALISED BASIC TRAINING

Attempts should be made at industry level to prepare a training programme that would develop the basic competencies required for safe work as well as the competencies required by first-line management, supervisors and safety representatives. Developers of this training programme should include labour, line management, safety officers and representatives, under the chairmanship of a training expert.

3.2 OTHER FACTORS THAT CONTRIBUTE TO ROOF AND SIDEWALL ACCIDENTS

3.2.1 OUTDATED TECHNOLOGY FOR HAZARD RECOGNITION

If an instrument could be developed to read the physical condition of a roof to a depth of say 3 m, providing reliable data regarding cracks, slips, fissures, etc. in the rock, sandstone or coal, the number of accidents would evidently be negligible. Such an instrument would ideally present a photograph such as an X-ray.

The NPI was informed that extensive research has already been done in this respect but that the results had been negative or at best clumsy and impractical. However, this is no reason to stop the research. The NPI would like to see this research continued, perhaps in collaboration with counterparts overseas.

3.2.2 AVAILABILITY OF ROCK ENGINEERING DISCIPLINE

The South African coal-mining industry needs many more rock engineers and rock mechanics on location at the mines. The NPI is prepared to state that unless this discipline is available at a mine for 24 hours per day, that mine runs at least a 25% increased risk of rock falls.

Training of all mining employees in the principles of rock engineering should become a top priority. Courses, already in existence, should be offered to the various employee levels, with the emphasis on shift overseers, face bosses, team leaders, equipment operators and their assistants, the sounding stick and pinch bar operator, and the safety representative.

The NPI recommends that surveyors and geologists who are already full-time employees at nearly all the mines, be given the opportunity to become multiskilled. They should be given the opportunity to become fully qualified rock mechanics. Courses could be offered, full-time, part-time or even partly by correspondence.

Smaller mines who cannot afford or justify the appointment of a graduate rock engineer could benefit by employing a multiskilled surveyor/rock mechanic or geologist/rock mechanic and thus have this much-needed discipline at their disposal 24 hours per day.

3.2.3 SUPERFICIAL AND UNCOORDINATED RECORDING OF ACCIDENTS AND NEAR ACCIDENTS

A centralised database should be available where all accidents and near accidents can be recorded. The mines should be provided with a document that would ensure comparable information between mines. The documented information should be summarised by individual mines at frequent intervals and subsequently shared with employees. At mine level this information should be used for learning purposes.

The Department of Mineral and Energy Affairs should also have access to the data. This would ensure an awareness of accidents and near accidents in other mines, the factors that caused them as well as precautions that had been implemented.

This centralised database should be user-friendly and accessible to researchers.

3.2.4 COMPARTIMENTALISATION OF SAFETY, TRAINING AND ENGINEERING

Mine management ought to ensure that training, engineering and safety are equally involved in the development and maintenance of the safety strategy of the mine. At forum discussions these groups should present their views of the safety situation at the mine and suggest ways in which problems could be addressed. The experience of individual mines should be shared on industry level.

4. SUGGESTED SECONDARY OUTPUTS

Eight secondary outputs were suggested when the project proposal was developed:

4.1 INDICATION OF ACCESSIBILITY AND UNDERSTANDING OF STANDARDS PERTAINING TO ROOF AND SIDEWALL STABILISATION

Most employees seemed to feel that they understood the standards. However, the engineers and other senior employees doubted the accuracy of this understanding.

The standards were found to be in place at all the mines. All employees had access to them - if they could read and understand the language.

The low literacy level and lack of a common language made the standards and COPs inaccessible to the majority of employees.

4.2 COMPETENCIES REQUIRED TO CREATE A SAFE WORKING ENVIRONMENT

The following basic competencies were identified:

- Physical health
- Observing skills
- Investigating skills
- Teamwork
- Safety knowledge
- Knowledge of rock mechanics.

The competencies required by machine operators were identified as:

- Physical health
- Coordination
- Dexterity
- Quick reaction time
- Estimation skills
- Equipment knowledge
- Basic knowledge of rock mechanics.

In addition to the basic competencies, safety representatives seemed to require the following competencies:

- Assertiveness
- Motivating skills
- Evaluating skills
- Knowledge of rock mechanics
- Reporting skills
- Hazard identification skills.

In addition to operational and safety training, first-line management and supervisors require the following competencies:

- Disciplining skills
- Controlling skills
- Assertiveness
- On-the-job training skills
- Communication skills
- Team management skills
- Observing skills
- Listening skills
- Organising skills
- Knowledge of safety aspects and data control/rock mechanics
- Knowledge of all work processes and operation of all machines.

4.2.1 A DEVELOPED COMMUNICATION NETWORK

It is imperative that the communication network should deal with organisational, general job-related, personnel and people issues as well as safety issues. Communicating safety issues only would not enhance trust and credibility. It is assumed that all issues would be communicated by the suggested network.

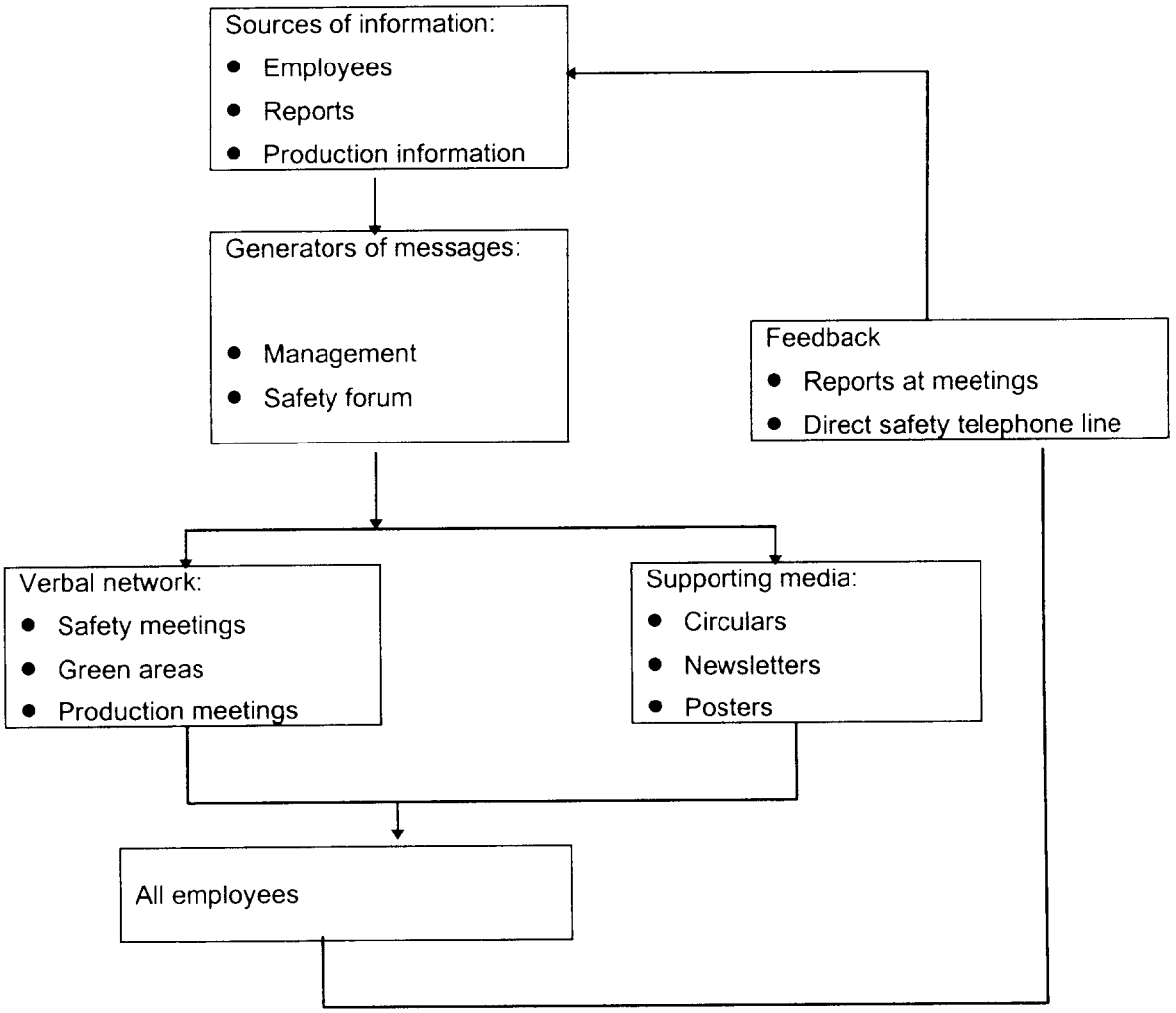
- The message generators would be a safety forum and mine management. The safety forum would include safety officers, the safety representatives, training officers and line management.

- The sources of information would be the employees, reports of accidents and near accidents, and production information.

- The communication channel would be the verbal network by means of meetings between different job levels and operational groups.

- The supporting media would be newsletters, circulars and posters.

- The recipients would be all employees at the mine.
- Feedback would be verbal to the superior or safety forum, or via a direct line to the safety officer.
- Messages would be sent daily, with a clear distinction between messages to create awareness and messages to warn of real dangers during the next shift.



4.2.2 DEVELOPED RESEARCH INSTRUMENT

See Appendix 1.

4.2.3 COMMUNICATION STRATEGY

See 2.1.5.1 to 2.1.5.3.

4.2.4 STRONG AND WEAK POINTS IN EMPLOYEE ATTITUDES

Strong points

- Employees are aware that they work in dangerous conditions
- They will not go under unsafe roofs only to impress co-workers
- Employees mainly go under unsafe roofs because they work there
- Supervisors are perceived as more caring than management
- Supervisors will not normally order employees to enter unsafe areas
- Most employees consider training as a solution

Weak points

- Employees go under unsafe roofs despite being aware of the danger
- Workers are complacent about roof and sidewall accidents
- The safety representative is not perceived in a positive light
- Warning signs are not effective due to a lack of maintenance
- Some supervisors order employees to go under unsafe roofs
- Employees do not feel free to question a supervisor when they are ordered to go under unsafe roofs

4.2.5 SAFETY PROCESSES TO BE BENCHMARKED

- Recording accidents and near accidents
- Development of a centralised database
- Hazard identification practices
- Communication of hazardous situations

4.2.6 A COMMUNICATION MODEL

See 4.1.3.

5. IN SUMMARY

The project team set out to establish why employees go under unsafe roofs and ignore unsupported sidewalls. The team members came to the conclusion that it is impractical to study one aspect of safety behaviour in isolation as any conclusions in respect of this aspect would apply to most other mine safety issues.

It is therefore recommended that the findings and recommendations of this project be shared on an industry level. Workshops should be arranged so that the project team can discuss these findings and recommendations with all the stakeholders to ensure that the necessary steps are taken. The mining industry would therefore benefit much more than merely having established why employees ignore unsupported, unsafe roofs and sidewalls.

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PERSONS CONSULTED

Mr D Baker, Department of Mineral & Energy Affairs, Pretoria

Mr M Poultney, Department of Mineral & Energy Affairs, Witbank

Mr L Naudé, Department of Mineral & Energy Affairs, Pretoria

Mr K Hewitson, Department of Mineral & Energy Affairs, Dundee

Mr P Hunt, Department of Mineral & Energy Affairs, Johannesburg

LIST OF PRESENTATIONS AND PUBLICATIONS EMANATING FROM THE PROJECT

Hamilton-Attwell A 1996 - Reasons for unsafe acts and neglect in side and hang-wall accidents - South African Institute of Mining and metallurgy symposium. Mintek, Randburg.

Hamilton-Attwell A 1997 - Identification of causes of unsafe acts or neglect resulting in roof and sidewall accidents - 27th International Conference on Safety in Mines Research Institutes, New Delhi.

APPENDIX 1

QUESTIONNAIRE TO DETERMINE THE KNOWLEDGE, ATTITUDES AND BEHAVIOUR OF MINE MANAGEMENT WITH REGARD TO ROOF AND SIDEWALL ACCIDENTS

SIMRAC QUESTIONNAIRE

SECTION 1: BACKGROUND INFORMATION

We need the following information to process the questionnaire information. Please do not put your name or employee number on the questionnaire. The responses are totally confidential and anonymous. We need the following information only to determine trends and not to identify people.

1. Which mine do you work?

Koornfontein	1
Welgedacht	2
Kriel	3
New Denmark	4
Tavistock	5
Leeufontein	6
Durnacol	7
Tweefontein	8
Delmas	9

2. Which section/work area do you work in?

Planning	1
Production	2
Maintenance	3
Human resource management	4
Training	5
Safety	6
Security	7
Other (Specify)	8

3. What is jour job title?

Mine manager	1
Underground manager	2
Section manager	3
Mine overseer/Mine Captain	4
Shift overseer/Shift Boss	5
Miner (Contractor)	6
Engineer (Maintenance)	7
Artisan	8
Head of security	9
Security staff	10
Support staff	11
Other (Specify)	12

4. How old are you?

5. How many years have you been working in mines?

6. How many years have you been in your current position at this particular mine?

7. Are you responsible for determining safety standards?

Yes	No
1	2

SECTION 2: GENERAL ISSUES

The following section deals with general issues regarding roof and side wall accidents.

8. How often do employees in your section/work area go into areas of known unsafe roof and/or side wall conditions?

Never	Hardly ever	Sometimes	Often	Constantly
1	2	3	4	5

9. Do you think employees in your section/work area are aware that they are going under unsafe unsupported roof?

Definitely not	No	Sometimes, sometimes not	Yes	Definitely, yes
1	2	3	4	5

Why do you think will employees in your section go under unsafe unsupported roof:

	Issue	Definitely not	No	Sometimes, sometimes not	Yes	Definitely yes
10.	It is where they work	1	2	3	4	5
11.	To do inspections	1	2	3	4	5
12.	They want to produce as much as soon as possible and therefore do not want to wait for the roof to be supported	1	2	3	4	5
13.	The supervisor tells them to do something that involve going under unsafe unsupported roof	1	2	3	4	5
14.	They are so distracted by personal problems or fatigue that they forget that it is dangerous to go under unsafe unsupported roof	1	2	3	4	5
15.	They need to do something under unsafe unsupported roof that will only take a short time	1	2	3	4	5
16.	It is close to quitting time and they quickly want to finish a job	1	2	3	4	5
17.	They could avoid going a long distance to get something or to do something	1	2	3	4	5
18.	They have seen other people go under unsafe unsupported roof without getting hurt	1	2	3	4	5
19.	Other employees will think they are afraid if they do not go there	1	2	3	4	5
20.	Other (Specify)	1	2	3	4	5

Why do you think supervisors sometimes ignore employees who go under unsafe unsupported roof:

	Issue	Definitely not	No	Sometimes, sometimes not	Yes	Definitely yes
21.	They believe that it is very unlikely that the person will be hurt by a roof fall	1	2	3	4	5
22.	They have tried talking employees out of working under unsafe unsupported roof before, but they just would not listen	1	2	3	4	5
23.	They think the union will object to the use of disciplinary action against these employees	1	2	3	4	5
24.	They doubt whether mine management would support the use of disciplinary action in such a situation	1	2	3	4	5
25.	They are too busy taking care of production-related matters	1	2	3	4	5
26.	They think that they should not interfere because the miner knows about the risk he is taking	1	2	3	4	5
27.	They believe that if they reprimand a miner for going under unsafe unsupported roof, the person will become hostile and uncooperative	1	2	3	4	5
28.	Because supervisor occasionally go under unsafe unsupported roof themselves	1	2	3	4	5
29.	Other (Specify)	1	2	3	4	5

SECTION 3: STANDARDS

The next set of questions deal with the impact of safety standards on the creation of a safe mining environment.

How do you feel about the impact of safety standards on roof and side wall accidents?

	Issue	Definitely not	No	To some extent	Yes	Definitely yes
30.	Will the exact implementation of safety standards prevent side wall and roof fall accidents?	1	2	3	4	5
31.	Do employees in your section/work area really understand the safety standards?	1	2	3	4	5
32.	Do employees in your section/work area adhere to safety standards?	1	2	3	4	5
33.	Are employees in your section/work area familiar with the mine's Safety Code of practice?	1	2	3	4	5
34.	Are employees in your section/work area involved in formulating safe actions/ practices?	1	2	3	4	5

SECTION 4: COMMUNICATION

The next set of questions deal with the impact of communication on the creation of a safe mining environment.

	Issue	Definitely not	No	Sometimes, sometimes not	Yes	Definitely yes
35.	Does your supervisor discuss safety issues during work group meetings?	1	2	3	4	5
36.	Do you have a notice board in your working area with accident statistics on?	1	2	3	4	5
37.	Does your supervisor discuss potential safety hazards before the start of the shift with the employee?	1	2	3	4	5
38.	Do you feel the areas where there are unsafe unsupported roofs and side walls are marked clear enough?	1	2	3	4	5
39.	Do you have any posters in the mine to make employees conscious of the dangers of going under unsafe unsupported roofs and side walls?	1	2	3	4	5
40.	Do you regard your supervisor as a major source of information on safe behaviour?	1	2	3	4	5
41.	Do you regard your safety representative as a major source of information on safe behaviour?	1	2	3	4	5
42.	Do you regard your colleagues as major sources of information on safe behaviour?	1	2	3	4	5

SECTION 5: TRAINING

The next set of questions deal with the safety training you received.

	Issue	Definitely not	No	To some extent yes	Yes	Definitely yes
43.	Was the training you received about the identification of unsafe areas sufficient?	1	2	3	4	5
44.	Were you told during the safety training why it is dangerous to go under unsafe unsupported roof?	1	2	3	4	5

	Issue	Definitely not	No	To some extent yes	Yes	Definitely yes
45.	Will you be able to identify a potential roof or side wall hazard due to the training you received?	1	2	3	4	5
46.	Could you immediately use the training you received in the work place?	1	2	3	4	5
47.	Do you think that safety training should be updated?	1	2	3	4	5

SECTION 6: ATTITUDES

The following questions deals with how you feel about certain issues

	Issue	Definitely not	No	To some extent yes	Yes	Definitely yes
48.	Personally I am very reluctant to go under unsafe unsupported roof	1	2	3	4	5
49.	The thought of my colleagues thinking I am brave to go under unsafe unsupported roof is very pleasant to me	1	2	3	4	5
50.	The thought of my supervisor thinking I am brave to go under unsafe unsupported roof is very pleasant to me	1	2	3	4	5
51.	My supervisor never asks us to perform dangerous tasks	1	2	3	4	5
52.	My supervisor cares for me	1	2	3	4	5
53.	Mine management cares for us	1	2	3	4	5
54.	Employees in my section/work area place more emphasis on production than on safety	1	2	3	4	5

SECTION 7: THE PREVENTION OF UNSAFE BEHAVIOUR

Do you think the following will cause employees in your section/work area not to go under unsafe unsupported roof unnecessarily?

	Issue	Definitely not	No	Sometimes, sometimes no	Yes	Definitely yes	Not possible
55.	Better training about the dangers of unsupported roofs and side walls	1	2	3	4		5
56.	Ways to report employees that go under unsafe unsupported roof unnecessarily	1	2	3	4		5

	Issue	Definitely not	No	Sometimes, sometimes no	Yes	Definitely yes	Not possible
57.	Impose fines on employees that go there	1	2	3	4		5
58.	Impose fines on the supervisor of the employees that go there	1	2	3	4		5
59.	Take disciplinary steps against the employees that go under unsafe unsupported roofs	1	2	3	4		5
60.	Take disciplinary steps against the supervisor of the employee that go under unsafe unsupported roofs	1	2	3	4		5
61.	Reassign those employees to work in a different face crew where miners are known to be very safety conscious	1	2	3	4		5
62.	Post more warning signs around areas of unsupported roof	1	2	3	4		5
63.	Company safety officials should make frequent unannounced inspections to the face areas	1	2	3	4		5
64.	Publicly post the names of those who go under unsafe unsupported roof	1	2	3	4		5
65.	Urge employees to anonymously report crews in which people work under unsafe unsupported roofs unnecessarily	1	2	3	4		5
66.	Urge miners to tell a Union official or Union safety committee member about incidents	1	2	3	4		5
67.	Other (Specify)	1	2	3	4		5

SECTION 3: STANDARDS

68. What according to you is the main cause of roof and side wall accidents?

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COMMENTS

Please print your comments, suggestions or ideas in the space below. Your comments will be typed and reported anonymously.

Please identify the subject of your comment by writing the appropriate topic number in the left-hand column at the beginning of your comment. A list of topic numbers has been provided below. Feel free to write an many comments as you wish, but please identify the topic number for each comment.

1. Reasons for going under unsafe unsupported roof
2. Mine safety standards
3. Communication
4. Training
5. Safety attitudes in mines
6. Ways to prevent unsafe behaviour

TOPIC NUMBER	COMMENTS

Thank you for your participation. Please put the questionnaire in the envelope and return it to the HR manager.