SIMRAC

Final Report

Title: INVESTIGATE THE ROLE OF ENVIRONMENTAL FACTORS IN CAUSING OR CONTRIBUTING TO UNDERGROUND ACCIDENTS IN GOLD AND PLATINUM MINES

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Executive Summary

The present report, which documents the findings of SIMRAC Project GAP 203, should be of interest to management, safety and environmental control personnel at mine level, as well as employee representative organizations and individuals at Group level concerned with the safety and environmental control aspects of operations at their constituent mines.

Following a review of relevant literature on previous research findings, which offered limited insight into the environment's effects on safety and accident occurrence, three different but complementary methodologies were adopted. These compromised:

- the acquisition and analysis of supplementary environmental data in respect of reportable underground accidents;
- safety hazard risk assessments at gold and platinum mines to consider the potential for unfavourable environmental conditions to contribute to underground accidents, and
- an employee perception survey regarding the importance of environmental conditions in accident causation.

All three elements of the methodology were consistent in their findings that environmental conditions play a subordinate role in the occurrence of underground accidents. Even the employee perception survey, which indicated a somewhat greater environmental influence than determined by accident investigations and safety hazard risk assessments, found the environment's influence on safety to be half as important as that of other issues considered (equipment & materials, standards & procedures, management & supervision and training & competence). The perception survey also found that production workers in stopes and development ends assigned greater importance to environmental factors than did employees in other workplaces, and that workers regard the environment as a more important contributor to accidents than do supervisors/managers. However, even these two groupings (production employees and workers in general) perceived the role of environmental factors to be subordinate to other factors in accident causation.

The three methodologies were also relatively consistent in their ranking of environment factors among themselves, finding visibility and heat to be more important than noise and ergonomics (the latter representing restricted space and vibration).

The largely indirect influence of the environment on human performance, vigilance and thus, safety has confounded previous efforts to quantify its role and it must be acknowledged that the current programme of work was similarly affected. It is observed that a limited culture of root cause analysis in accident investigations and the nature of the data capture form used may have resulted in this element of the methodology underestimating the contribution of environmental conditions, although the risk assessments and employee perception survey would not have been so affected. Nevertheless, it is suggested that workplace observations of human performance and errors under various environmental conditions represent more fertile ground than accident investigations for developing a better understanding of the environment's influence. This statement is based on the fact that accidents are relatively infrequent occurrences and also that their investigation may often be limited to the identification of an immediate cause and sometimes limited by a defensive posture on the part of the investigator, particularly where he is also the responsible line supervisor.

While no strong support can be demonstrated for recommendations to expand the current accident reporting system to more directly include environmental factors, a more uniform approach to the investigation of accidents is suggested, with this process being undertaken by safety specialists rather than the responsible line supervisors. It is also suggested that any environmental data gathered in respect of accidents be accompanied by parallel normalizing data, in order to enable correlations between the distributions of environmental conditions and data relating to accident occurrences.

Suggestions are made for the consideration of interventions to reduce heat stress and improve lighting, particularly in stopes, but with cognisance of the environment's subordinate role in accident causation and the need for favourable economic evaluations and cost benefit analyses.

The current programme of work has further indicated that initiatives to reduce accident rates should focus mainly on non-environmental factors, particularly those relating to the observance of safe work standards and the use of a participative approach to safety management and the formulation of safe work standards.

Preface

While the influence of some factors contributing to the occurrence of underground accidents is reasonably well understood, e.g. mining conditions, equipment/material issues and certain aspects of human error, the role of unfavourable environmental conditions has not been adequately characterized or quantified. Their contribution is readily apparent where extreme conditions directly result in an accident but there may be a far greater potential for their indirect influence to be exerted by reducing workers' vigilance and increasing propensity for slips, lapses, mistakes and violations, unintentional and otherwise. It is these human failings that are frequently identified as having caused the accident, with little or no consideration of the environment's possible underlying influence. An example of major significance could well be the addressing of heat as a direct cause of heatstroke and other heat disorders having substantially reduced their incidence while also contributing indirectly to reductions in human errors and hence, accidents.

The purpose of the programme of work documented in the present report is to characterize and, as far as possible, quantify the role of environmental factors in causing or contributing to underground accidents, in order to enable their prioritization for possible amelioration and thus contribute to a reduction in the incidence of such occurrences.

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Glossary of Abbreviations

Term	Abbreviation
centimetres squared	cm^2
chi-squared statistic	X^2
decibels	dB
degrees Celsius	°C
DME	Department of Minerals and Energy
GAPEEAG	Gold and Platinum Environmental Engineering Advisory Group
hand-arm vibration	HAV
hand-arm vibration syndrome	HAVS
metres	m
metres cubed	m^3
metres squared	m^2
millicalories	mCal
milligrams	mg
Mine Medical Officer	MMO
Occupational Health Centre	OHC
Performance Shaping Factors	PSF
second	s
student t-statistic	t
whole-body vibration	WBV

1 Introduction

1.1 Project background

The negative impact of underground accidents on the lives of workers and on the profitability of gold and platinum mining has resulted in Industry placing increased emphasis on initiatives aimed at minimising these unfortunate occurrences. These have included programmes aimed at ensuring the stability of underground workings, the development of means to enhance the safety of transport systems and of mining operations themselves.

Fundamental to the safety and productivity of any task are the environmental conditions under which it is performed. Certain aspects of the environment have long been recognized as critical and received considerable industry attention over and extended period, e.g. heat. Although this was an issue of concern mainly related to workers' health, safety benefits have undoubtedly resulted. In order to ascertain the scope for improving safety through addressing environmental conditions, SIMRAC and, more specifically, SIMGAP identified the need for an investigation of the environment's impact on safety and accident occurrence, considering both direct causal and indirect contributory effects.

1.2 Relevance of previous research

The negative impact of unfavourable environmental conditions on safety has been the subject of numerous laboratory and industrial studies documented in the literature. However, these have made only limited progress towards validly quantifying the relationships between environmental conditions and accident occurrence, mainly because the environment's influence on safety tends to be indirect, acting via effects on human performance. Laboratory-based studies have been used to measure human performance, accuracy and vigilance during the execution of various repetitive and simple cognitive tasks while environmental conditions are manipulated. However, indirect inferences must then be extended to the workplace to predict the likely or potential safety impact of the environmental factor being considered within the context of complex operations and processes.

Industrial-based studies have attempted to establish the influence of one or another environmental factor on accident rate but have generally failed to adequately match the non-environmental characteristics of the workplaces being compared. In some instances environmental conditions have even been incorrectly identified as causal factors, when they were, in fact, the result of processes or operations in the workplace. Such shortcomings have led to several reviewers questioning the validity of these findings, leaving the issue of the environment's impact on safety largely unresolved.

An important finding of research into the role of human factors has been that increased stress, regardless of its origins, can induce improvements in performance, but these are generally followed by severe collapse *(Swain and Guttman, 1983:77)*. While models for such effects have been developed, these have been within the context of nuclear power plant (NPP) control rooms or military operations. Stress in the case of the former would tend to be psychological, as NPP control rooms are reasonably comfortable in terms of the physical environment. Stress during military operations can have its origins in the pressures of the task or those imposed by the physical environment indicating greater relevance to mining, but the effects identified and the understanding provided by the models developed thus far have been qualitative.

1.3 Purpose of current research

The limited relevance of laboratory-based studies to physical work situations and the questionable validity of many industrial studies made it necessary to investigate the relationship between unfavourable environmental conditions and accident occurrence directly and within the context of mining. The specific need was to quantify the environment's role in causing or contributing to underground accidents in gold and platinum mines.

The purpose of establishing the work environment's impact on safety is threefold, namely:

- to determine the importance of environmental factors relative to other known contributors to accidents;
- to identify among environmental contributors those of greatest importance, and

- to enable the evaluation of potential benefits to be gained by ameliorating unfavourable environmental conditions.

The value of these three aspects would be in facilitating mine-specific assessments of the environment's impact on safety and the motivation of measures aimed at ameliorating any negative influences, be they actual or potential.

1.4 Outputs

The outputs of the current project can be summarized as follows:

- a report identifying the role of environmental factors causing or contributing to underground accidents in gold and platinum mines;
- recommendations regarding the inclusion of environmental factors in the accident reporting system, and
- recommendations for further work to improve safety, where appropriate.

1.5 Overview of methodology

The approach adopted for this programme of work involved, firstly, a review of relevant literature to establish the current understanding of the environment's impact on safety and, secondly, a three-pronged study with input from participating mines. The latter comprised:

- the acquisition of supplementary data on environmental conditions prevailing at the time of underground accidents;
- safety hazard risk assessments, and
- a survey of mine employees' perceptions regarding the potential for unfavourable environmental conditions to result in accidents.

The information derived from these three sources was analysed and correlated, in order to provide a balanced assessment of the environment's role in the occurrence of underground accidents and to identify the most important environmental contributors.

1.6 Report structure

The present report employs a traditional structure which can be summarized as follows:

1. Introduction
2. Previous research findings
3. Methodology
4. Results and discussion
5. Conclusions and recommendations
6. References

Results and the discussion thereof are presented in a single section, in order to facilitate their evaluation by the reader. The section concludes with a summary of the results and discussion.

The appendices contain a number of documents that could be characterized as instruments used for the acquisition of data. These include the form for recording supplementary data in respect of environmental conditions at the time of underground accidents and the various versions of the questionnaire utilised during the employee perception survey.

2 Previous research

In order to ascertain the current state of knowledge with regard to the environment's impact on safety in the workplace, a review of relevant literature was conducted. The purpose was to ensure that the findings of previous research were beneficially applied in delineating the current project's research scope and designing its methodology.

The basic approaches of previous research in the field are described and their relative strengths and weaknesses discussed. Each of the environmental factors that are relevant or potentially relevant to safety is considered in turn. The mechanisms through which environmental factors are understood to exert their influence are discussed and major findings summarized and considered in terms of their relevance to underground mining operations.

2.1 General literature evaluation

In considering the somewhat inconclusive findings of previous research examining the influence of unfavourable environmental conditions on human performance and accident rate, it is essential to take cognisance of the limitations inherent in the two basic approaches that have been applied. These are discussed in the following two sub-sections.

2.1.1 Laboratory studies

Laboratory-based studies have generally considered human performance, accuracy and/or vigilance, through the measurement of some cognitive task using either a computer monitor and keyboard or a purpose-designed test apparatus. While such studies have provided for adequate control in terms of environmental conditions and experimental design, this approach requires that indirect inferences be drawn between human performance in the laboratory and that in the workplace. The environment's impact on vigilance is certainly relevant within the context of safety but the inferences become tenuous where workplace tasks are more complex and the appropriate response or course of action depends on a number of independent and sometimes conflicting criteria. Furthermore, human performance and vigilance measured during purely cognitive tasks are of limited relevance to the more physical tasks performed by mineworkers.

Attempts have been made to incorporate laboratory findings into models for Human Reliability Assessment *(e.g. Swain and Guttman, 1983)*, in which the possibility of a human error is predicted by the status of various performance shaping factors (PSF). However, environmental factors do not feature prominently among the PSFs included in these models which are also still of a relatively qualitative nature.

2.1.2 Workplace studies

Industrial or workplace studies, while offering the advantages of considering performance during genuine work tasks and enabling direct measurement of error and accident rates, suffer from difficulties with experimental control. This inherent weakness manifests itself, firstly, in the control of environmental conditions, which are largely dictated by processes and operations in the workplace. Prospects for altering or manipulating environmental parameters are limited, particularly where such interventions would be aimed solely at enabling the investigation of environmental effects. This constraint has compelled many researchers to compare different workplaces and, very often, different types of workplaces, in order to examine the effects of environmental conditions on human performance or error and accident rates. It is at this point that a secondary limitation of workplace studies often manifests itself.

In order to validly assess the effect of a particular environmental factor on performance or accident rate all other environmental aspects, both physical and organizational, must be closely matched between the two workplaces being compared. This requirement has rarely been met, leading to findings best described as questionable. An illustration of this point would be the conclusion that a high accident rate in the construction industry is attributable to excessive noise levels when the textile industry is used as the basis for comparison. Clearly such a conclusion would be based on failure to recognise the fact that excessive noise at construction sites, like the higher accident rate, is an effect of the machinery used and activities undertaken. While the present example may be too extreme to regard as representative, it illustrates the sort of deficiencies reviewers have identified in workplace investigations of the environment's impact on performance and particularly safety.

Even where different workplaces and types of workplaces have been adequately matched for factors outside the scope of the investigation, industrial studies are susceptible to the so-called "Hawthorne effect", whereby workers' awareness of an investigation alters their behaviour and performance, this influencing the outcomes being measured. Such a case would be where the measurement of performance or error rate motivates workers to minimize the occurrence of negative outcomes and/or maximize those of positive ones.

In instances where conscious or unconscious awareness-induced changes in performance are successfully minimized, a secondary Hawthorne effect is still possible. This would manifest itself as changes in behaviour or performance in response to a change as such, rather than to the improvement or deterioration of environmental conditions. This secondary Hawthorne effect was demonstrated where performance and accuracy temporarily improved after workplace noise levels were reduced, with the improvement then being repeated after the original, higher noise levels were restored *(Broadbent, 1979:197)*.

Regardless of which approach has been adopted, laboratory- or workplace-based, the investigation of environmental factors' impact on safety has been complicated by the fact that the effects are largely indirect, acting via human performance and vigilance. Furthermore, for certain environmental parameters, moderately adverse conditions appear to improve accuracy and vigilance, by inducing increased arousal levels. This effect has been demonstrated for heat, noise and vibration.

It should be considered that accidents are relatively rare events, while errors are not. Therefore, far greater potential exists to learn from the analysis of errors but unfortunately, errors are readily detectable only in closely monitored production situations, e.g. factories.

2.2 Findings

The findings of previous research regarding the influence of environmental factors on performance, vigilance and safety are reviewed in the sub-sections which follow. The findings are evaluated and discussed in terms of their relevance to safety in underground mining.

2.2.1 Excessive environmental temperatures

The role of excessive environmental temperature is both direct and readily apparent in the occurrence of heat illnesses. However, like most environmental stressors, its influence on accident rate is also indirect, acting through effects on workers' cognitive and decision-making performance.

The literature relates instances where reduced environmental temperature was associated with improved accident statistics, although this was not proven conclusively *(e.g. Smith, 1984:365)*. As stated by *Kielblock and Schutte (1993:120)*, this can be explained through observations of thermally-induced deterioration in mental performance even before effects on physical performance become apparent *(Hancock, 1981:179)*. Such instances can result in reduced vigilance and/or failure to respond in the most appropriate manner.

Where work in heat involves physical effort, the effects of an environmental heat load are compounded by conflicting demands on the cardiovascular system to maintain thermoregulation and supply large muscle groups, which themselves add further stress through the introduction of metabolic heat. This results in a diminished capacity to maintain homeostasis and meet the physical demands of manual tasks, which can exacerbate physical stress, as well as create psychological stress. Clearly, such a situation is less than conducive to effective mental performance, implying potential impact on cognitive functions such as vigilance and decision-making processes, both of which can affect safety.

Vigilance, as determined by detection rate and sensitivity, has been measured in the laboratory for various levels of effective temperature (ET) *(ASHRAE, 8.13, 1993)*, where it was found that excursions from the so-called "comfort range" (19 to 23°C) improved performance with ETs as high as 28°C *(Poulton and Kerslake, 1965)*. However, vigilance was found to deteriorate at ETs from 31 to 36°C, particularly with continued exposure, the extent of decrement determined by duration and level of ET *(Poulton, Edwards and Colquhoun, 1979)*.

In general, these findings indicate that mild to moderate heat stress improves detection efficiency or vigilance, albeit temporarily, while the impact is negative at ETs $\geq$ 31°C and for extended exposure periods. If one accepts a linkage between detection efficiency and safety, the implication is that, within certain limits of temperautre and of time, mild to moderate thermal stress may temporarily reduce propensity for detection errors and, thus, the risk of accidents *(Davies and Parasuraman, 1982:172)*. However, it must be considered that laboratory studies involving purely cognitive tasks cannot be regarded as totally relevant to workplace tasks with a large physical component, although vigilance for hazard recognition could reasonably be regarded as such. While individual differences in fatigue, hydration, state of health, fitness and tolerance to heat would likely result in wide variations in performance among workers exposed to the same thermal conditions, what matters is the shift in average performance of the population.

Workplace studies of accident rate as a function of environmental temperature have indicated that a relationship does exist between these variables *(e.g., Smith, 1984 and Belding, Hatch, Hertig and Riedsel, 1960)* but both these sources point out that changes in organizational aspects may also have had some influence on accident rate. A 14-month study in a foundry/metal manufacturing plant that considered safety behaviour (as opposed to accident rate) found that unsafe work behaviour was least prevalent at "most comfortable" WBGT temperatures ranging from 17 to 23°C, and was decidedly more prevalent at both lower and higher levels. Furthermore, tasks involving higher metabolic workloads and greater safety risks showed the greatest escalations in unsafe behaviour outside the aforementioned temperature range *(Ramsey, Burford, Beshir and Jensen 1983)*. It must be pointed out that this is contradictory to the findings of *Poulton and Kerslake (1965)*.

The implications for mining appear to be that environmental temperatures outside the range of what is comfortable for workers performing physical tasks are likely to increase the propensity for errors and unsafe behaviour, as a result of negative impact on mental performance, vigilance and in all likelihood, motivation. It is particularly concerning that tasks which are more demanding and potentially more hazardous may be more susceptible to such effects. While mild to moderate heat stress may temporarily improve these aspects of performance, the effects of extended exposure and physical labour are likely to result in deterioration, as well as in deliberate omissions or short-cuts to reduce effort and concomitant heat stress. Unfortunately, such an approach to even the lowest level tasks increases the potential for accidents, if not immediately, at a later stage.

2.2.2 Noise

While the health effects of noise, both auditory (hearing loss) and non-auditory (psychophysiological effects) are well documented and in the case of the former, well quantified *(ISO 1999:1990)*, this is not so for the safety effects. It is equally apparent that noise-induced hearing loss and loud noise at unfavourable frequencies can directly affect safety by interfering with the perception of critical warning signals but such situations could also be regarded as the result of inappropriate employee allocation and signal selection, respectively.

Experienced industrial workers are well aware that in the presence of moderate noise (≤ 80 dB), verbal communication requires loud speech and careful listening, while in loud noise (85 to 95 dB) shouting is necessary (from close proximity, where the upper level is approached). Where communication during industrial operations is compromised the implications for safety are clear. However, the non-auditory effects of noise can also impact on safety, as in cases of distraction which may also involve irritation or annoyance and hence, a decline in performance.

Workplace studies of noise-induced effects on human performance and safety have been limited, in terms of both their numbers and their usefulness, the latter being the result of deficient methodologies. Such shortcomings have generally been caused by inadequately matching the workplaces being compared or, where a single workplace has been examined before and after noise reduction, the introduction of additional variables through concurrent improvement in other aspects of the environment (e.g. lighting or thermal conditions).

Among the industrial studies attempting to demonstrate a relationship between noise and accident rate, at least two have been favourably received by reviewers. In comparing two factories in the United States, *Cohen (1973:151)* found significant differences in accident rate between noise conditions of ≥ 95 dB and ≤80 dB. However one reviewer identified several variables not accounted for in the original research such as more modern facilities at the "low noise" factory, which incorporated improved lighting and a number of organizational enhancements over the "high noise" factory *(Broadbent, 1979:199).*

Nearly 50 years after its publication, a study by *Kerr (1950)* remains perhaps the only totally convincing demonstration of a positive correlation between noise level and accident occurrence. In considering the relationships between accident rate and 40 organizational and environmental variables across 53 departments of an electronics factory, Kerr determined a correlation coefficient of 0,4 for excessive noise. Only one of the 39 other variables was more closely associated with accidents, that being worker mobility or lack of a fixed work station.

Laboratory-based studies of noise effects have been more successful in demonstrating relationships but the results are far from unequivocal, due to differences in experimental design, the level and frequency distributions selected for the noise condition, as well as the indirect mechanisms by which noise exerts its influence.

Performance during simple choice, reaction time, single-source vigilance and psychomotor tasks is relatively unaffected by continuous noise at levels of 90 dB or above and even appears to benefit from noise at more moderate levels *(Broadbent, 1979 and Davies and*

Davies, 1975). The explanation offered is that noise, like heat, increases arousal level and attention directed towards the assigned task. However, more complex tasks in loud noise yield consistent decrements in performance, characterised by increased errors and response times despite the overall work rate being relatively unaffected *(Davies and Parasuraman, 1982:166)*.

Broadbent (1979) summarized the conditions under which loud noise consistently reduces vigilance or detection performance as:

- level > 95 dB
- indistinct or unclear signals
- task situation which does not encourage caution or is undemanding, i.e. a perceived unlikelihood of signal occurrence
- task which is of considerable duration and without interruption, i.e. monotonous

These conditions appear to bear considerable affinity with many mining tasks, implying that noise has the potential to reduce vigilance and increase accident rate.

An important aspect of noise-induced effects on performance is that attention is re-apportioned during multi-component tasks, such that components perceived as important are given greater attention, to the detriment of those regarded as less important or less likely to arise *(Hockey 1970 and 1973)*. According to one reviewer, such effects, while beneficial to routine components, decrease the efficiency with which unexpected events are dealt with *(Broadbent, 1970)*. This may imply an increased risk of accidents where loud noise induces greater attention on routine and, ostensibly, more important task components, thus reducing capacity to detect sudden warning cues *(Wilkins and Acton, 1982)*. Such effects, together with signal masking by loud noise and/or the use of hearing protection and/or the presence of pre-existing hearing loss could have considerable potential to result in accidents.

Although instances of loud noise masking incidental cues and intentional signals or verbal warnings have been recorded in individual accident reports, no comprehensive analysis of such occurrences appears in the literature. The same is true for the use of hearing protection, pre-existing hearing loss and its exacerbation by the use of hearing protection.

Investigation of these effects would perhaps be best addressed by extended longitudinal studies or by considering large numbers of detailed accident reports *(Wilkins and Acton, 1982)*. To date, the literature continues to provide only anecdotal discussions of these issues with no convincing analyses apparent.

2.2.3 Vibration

Vibration, like noise, is a trauma-inducing physical agent and the two even share common origins, i.e. vibrating machinery components and/or structures. Vibrational energy transmitted to the surrounding air produces sound or noise but where such energy is largely confined within a structure, the result is vibration. Admittedly, excessive vibration can damage equipment or components which, in itself, could lead to accidents. However, the present concern is with vibrational energy transmitted to workers during the course of machinery operation and its potential to cause accidents, normally through interference effects. Similarly, the health effects of vibration exposure are excluded from this review, given the focus of the current project.

Vibration acting on humans is classified according to the path by which it reaches the subject. Where transmission is via a supporting structure (e.g. a floor, deck or seat) and affects the entire body to a greater or lesser extent, the term whole-body vibration (WBV) is applied. Where vibrational energy enters the body through the hands, wrists and arms, it is termed hand-arm vibration (HAV) or segmental vibration. Although some workers, depending on the machinery and how it is operated, can be exposed to both types simultaneously with compound effects, the two are considered separately, in their respective sub-sections which follow.

2.2.3.1 Whole-body vibration

In 1974 it was estimated that, of the 8 million workers in the U.S. exposed to occupational vibration, 6,8 million or 85 per cent were exposed to WBV. The majority of these were operators of heavy equipment and vehicles such as buses, trucks and aircraft *(Wasserman, Badger, Doyle and Margolies, 1974:37)*. With regard to mining, operators of vehicles (track-bound and otherwise) and mobile equipment were identified among those exposed.

The effects of vibration are mainly determined by its amplitude at resonant frequencies, where maximal energy transfer occurs and induces sympathetic vibrations in the body. In this regard, body resonance occurs at 4-8 Hz, with tolerance being lowest to vibrations in the vertical plane *(Poulton, 1977:446)*. Although the shoulders are generally most affected, other notable effects of vibration are the blurring of vision and reduced precision of limb movements *(Poulton, 1977:448)*. These effects imply considerable potential for impact on the safe operation of equipment where the operator is standing or seated on the machine, particularly mobile equipment traversing uneven terrain.

Laboratory studies have found that WBV in the vertical plane at a frequency of 5 Hz reliably enhances visual detection performance during simple monitoring tasks of 30- and 60-minute durations *(Schoenberger, 1967:1267 and Wilkinson and Gray, 1974:4, respectively)*. While initially surprising given the critical frequency and direction of the stimulus, one reviewer attributed the better performance of the vibration-exposed subjects to an increased arousal level induced by voluntary muscular tension in response to vibrational stress. The explanation offered was that muscular tension not only reduced the amplitude of vibration at the shoulders by half, minimizing interference with vision, but also acted as an arousal stimulus, thus improving vigilance *(Poulton, 1977:448)*.

While the observations and explanation related above are not disputed, the limited durations of the tests give rise to two questions:

- firstly, for how long can the increased arousal level be maintained by voluntary muscular tension, since a state of increased arousal tends to be temporary, if not transient, and
- secondly, whether negative effects of muscular and psychological fatigue would emerge during longer exposures, particularly in the presence of other stressors, environmental or otherwise.

Another point to be considered is that visual detection performance was influenced by feedback to subjects regarding their results. The study employing the 30-minute task indicated that continuous performance feedback yielded improved detection rates within both the exposed and the unexposed groups, but with comparatively better performance among the former. The 60-minute task revealed that the expectation of post-exposure feedback resulted in better detection performance among both the experimental and control groups but with the unexposed control subjects performing comparatively better.

While the above results indicate that vibration stimulus and performance feedback can both influence simple visual detection outcomes, the latter factor is of questionable relevance to the workplace, unless it can be regarded as a valid surrogate for performance monitoring or supervision. In this regard, even the findings regarding the effects of vibration on simple visual monitoring performance are of limited relevance to workplace tasks involving complex monitoring and responses, particularly in the case of mobile equipment operators who function both as monitors and as controllers. As is the case for a number of other environmental stressors, laboratory studies have yielded conflicting findings which are often convoluted by the consideration of factors beyond present concerns, while workplace findings are limited, and in the case of WBV, virtually non-existent with regard to safety. This is likely a result of research focusing mainly on the health effects of WBV. In order to provide some perspective for considering the potential for WBV to impact negatively on safety, its major physical effects are summarized below:

- Interference with muscular activity and maintenance of posture
- Increased heart rate and blood pressure, with constriction of blood vessels to the extremeties affecting muscular function
- Increased respiratory rate with hyperventilation in some individuals
- Gastrointestinal effects
- Motion sickness with nausea, vomiting and disorientation

Although individual susceptibility will play a role in determining whether these effects manifest themselves it would seem prudent to remain cognisant of WBV's potential to impede safe equipment operation through its impact on vision and precision of limb movement, as well as through fatigue, particularly under otherwise adverse environmental conditions. Such effects would be more apparent in cases of inadequate equipment maintenance or operators being in some way incapacitated. However, the literature yields nothing to counter the position that, provided equipment does not generate vibration at levels beyond the range that would be expected for a normally functioning machine, the potential of WBV to impact on safety should be of limited concern.

2.2.3.2 Hand-arm vibration

In contrast to WBV, hand-arm vibration (HAV) is well documented in the literature with regard to its health effects, which are more clearly defined, more localized (in terms of body parts involved) and more capable of causing debilitation among exposed workers than the effects of WBV. However, previous research does not include consideration of HAV as a safety hazard, despite what some might regard as its potential to interfere with the controlled operation of equipment, hand-held or otherwise. Such interference effects could be more likely where operators suffer from vibration-induced pathology that affects fine motor function.

No epidemiological studies have been documented for hand-arm vibration syndrome (HAVS) in the South African mining industry and likewise, no clinical reports of its incidence are apparent. Although this could be regarded as an indication that it does not occur to any appreciable extent, it may be useful to examine the factors associated with its occurrence in terms of their prevalence and thus, their potential to contribute to HAVS or to accidents locally. Causal factors identified during epidemiological studies elsewhere include:

- HAV exposure in the range of 6 to 1 000 Hz
- Long-term exposure
- Continuous exposure
- High grip force on machine handles
- Low-mass machine tools
- Cold working conditions
- Individual susceptibility

(Taylor and Brammer, 1982:7)

With regard to hand-held rockdrills, a principal source of HAV underground, only the first two factors, vibration within the critical range and long-term exposure could be regarded as being prevalent, the latter to an increasing extent with workers' employment patterns being more stable than was previously the case.

Continuous exposure and high grip force on handles can both be excluded on the basis of machine drill operators' tendency to release their grip once the drill is collared and to reassert it only intermittently during the drilling cycle. Similarly, low mass of machine tools, which indicates a limited capacity to damp vibrational energy, does not apply to the rockdrill, regardless of whether it is of the pneumatic or water-hydraulic type.

Cold working conditions, which have combined with the traumatic effects of HAV as a significant contributor to HAVS among forestry and shipbuilding workers in cold climates *(Gemne, 1982:244)*, are not relevant to South African gold and platinum mines. Although localized cooling of drill operators' hands can occur as a result of water spillage and compressed air leaks around the drill, such instances would be intermittent given the way in which these machines are normally operated.

Individual susceptibility may be a factor for those few who are more vulnerable than the rest of the population but their effect on the overall prevalence of HAVS would be minimal.

Other factors which have been linked with HAVS include drill operation in an upward direction *(Ashe and Cook, 1962:339)*, incentive work *(Behrens, Taylor, Wilcox, Miday, Spaeth and Burg, 1984:371)* and noise exposure *(Cohen, 1977:36)*. All three of these factors have at least some relevance to gold and platinum mining.

While some of the factors having secondary associations with HAVS may occur locally, general absence of the major causal factors would appear to indicate a minimal likelihood of an appreciable incidence of HAVS and quite likely (although not necessarily) of negative effects on safety.

The literature provides no insights regarding the potential for vibrating control levers to impede the safe operation of fixed or mobile equipment. Although it may seem reasonable to surmise that this sort of vibration could interfere with the more subtle aspects of operation, this would be more likely to affect efficiency than safety.

In summation it must be said that the literature documenting previous research of hand-arm vibration provides no indication of its impact on safety and the preceding section has attempted to consider the potential extent to which such effects may exist.

2.2.4 Lighting and visibility

Among the environmental factors considered in the current review, lighting is the only one for which a consistent correlation with accident rate has been demonstrated and quantified *(Lewis, 1986:3-4)*. The reason for this unequivocal relationship is that lighting, unlike other environmental factors, directly influences the efficiency of what is arguably the principal source of information in potentially dangerous situations. While the presence of visibility inhibitors such as dust, mist, fog, smoke or foreign objects in the eye may appear to exert their influence less directly, this is more likely the result of difficulties with their quantification. Although the indisputable influence of lighting and visibility on safety obviated the need for clarification through the literature, at least two local studies appear pertinent. A laboratory study employing a simulated mining hazard identification task under various thermal, noise and lighting conditions found that subjects' best performance coincided with the least stressful combination of conditions, i.e. low temperature, low noise and high illuminance level *(Pace and Barnes, 1979:14)*. However, subjects' worst erformance occurred under conditions of low temperature, high noise and low illuminance. While noise acted alternately as a performance inhibitor or enhancer, depending on temperature level, lighting consistently enhanced detection performance at high levels and inhibited it at low levels. The conclusion was that improved stope lighting would enhance hazard identification and thus, the safety of mineworkers.

A comprehensive study of all aspects of hanging wall examination and remediation found that 96 per cent of participating mineworkers indicated that poor lighting caused difficulties in performing these vital operations *(Peake and Ashworth, 1996:21)*. This identification of poor lighting as an interference factor was based on workers' awareness of its direct effects and it appears reasonable to surmise that the indirect effects, of which workers may have been less aware, could also be significant.

3 Methodology

As stated in the introduction, the project's research methodology employed three principal sources of information:

- supplementary data in respect of environmental conditions at the time of underground accidents;
- safety hazard risk assessments, and
- employees' perceptions regarding the likelihood of unfavourable environmental conditions resulting in accidents.

These were selected for their ability to complement one another and contribute to a balanced assessment of the importance of environmental factors in accident causation. At one extreme of the methodology is the accident investigation component, selected to provide a large amount of mainly quantitative data. The safety risk assessments, on the other hand, were expected to yield a smaller quantity of data tending to be more subjective but also more analytical and cognisant of root causal contributors, as well as immediate causes. The employee perception survey component was seen as a means of accessing a considerable body of knowledge and insight gained through mine employees' collective work experience and of bridging or correlating the findings of the other two techniques. It was also regarded as important to determine employees' views, given the contribution of human acts and omissions to accident occurrences observed locally and cited in safety literature.

The methods by which the three sources of data were utilized are detailed in their respective subsections, which follow. Depending on the complexity of the data obtained and its format, appropriate means of analysis were selected and applied. These are described in the relevant subsections which follow.

3.1 Accident investigations

During the first year of the project, a number of gold and platinum mines were approached for assistance with the acquisition of data relating to environmental conditions at the time of reportable underground accidents. Six gold producers expressed their willingness to assist, with no positive response from any of the platinum mines approached.

The gold mines participating during the first year submitted returns relating to a total of 73 reportable accidents, the bulk of which come from three mines. In comparison with the original target of 500 accident investigations, the total number of submissions received was deemed inadequate for meaningful analysis and trend identification. Difficulty in interpreting and completing the original data capture form (Appendix 1) was cited as a major reason for the limited response, a criticism supported by the fact that many of the forms submitted were incorrectly completed.

3.1.1 Instrument for data acquisition

In accordance with experience gained during initial attempts and input provided by Group Environmental Engineers, Union and DME representatives, the data capture form was extensively revised. The criterion was to achieve a reasonable balance between utility of information and ease of completion. The revised form, used during the second phase of data acquisition, is contained in Appendix 1.

3.1.2 Environmental factors considered

The data capture form considered a number of environmental factors regarded as potential contributors to accidents. The following aspects were included:

- heat stress and drinking water availability;
- visibility, comprising lighting and potential light transmission interference agents, e.g. visible dust, smoke, fog and eye protection;
- noise levels, warning signals and hearing protection;
- ergonomics, viz. whole body vibration, hand-arm vibration and available working space;
- information regarding the individual(s) who caused or contributed to the accident's occurrence.

The relevant information referred to in the last point comprised:

- occupation;
- experience in current occupation and workplace;
- time on duty and at the location of the accident prior to the occurrence;
- level of physical exertion prior to the accident;

- results of most recent heat tolerance screening, audiometric, visual acuity and colour perception tests, and
- presence of any treated or untreated medical condition.

These aspects were included to provide insights regarding workers' capacity to function effectively under the prevailing environmental conditions.

3.1.3 Characterization and quantification of environmental conditions

A dual approach to quantifying each environmental factor was adopted. The first aspect involved witnesses' subjective characterization of conditions at the time of occurrence, in comparison with those at other workplaces of the same type on the mine and in comparison with conditions normally prevailing at the location of the accident. In addition, it was requested that any change in conditions immediately prior to the occurrence be characterized. These points of information were all provided by marking the appropriate "tick boxes", labelled in accordance with the environmental factor being considered. Additional space was provided to record circumstances or events that would account for any deviation from the norm or any sudden change in conditions immediately prior to the accident.

The second aspect of quantifying environmental conditions involved the recording of actual values for environmental parameters, either as observed when the accident was investigated or, alternatively, as reflected in the relevant ventilation report. In the latter instance the values reported could have been based on the pre-accident or post-accident ventilation report, depending on which was compiled nearer to the time of the accident.

3.1.4 Sources of data

Letters requesting assistance with the acquisition of supplementary environmental data in respect of underground accidents were circulated to selected mines, with copies of the revised data capture form. Mines were selected in collaboration with members of GAPEEAG and comprised 13 gold mines in five Groups and four platinum mines in three Groups. Where the mine's initial response was favourable, these approaches were followed up with meetings at the mine concerned, in order to explain the purpose of the research and the project's needs. Following a rather limited response from mines, some members of GAPEEAG intervened, resulting in an increase in the number of mines agreeing to participate and a considerable improvement in the submission of returns.

Six gold mines from three Groups and two platinum mines from two Groups ultimately provided supplementary environmental data with respect to 369 reportable underground accidents. Participating mines included seven "hot" mines and one "cool" mine, six of which employed conventional mining methods and two of which used mechanized mining methods.

3.1.5 Analysis of data

The data obtained were statistically analysed to identify significant effects and trends. It had been intended to obtain data on the distribution of each environmental parameter for normal working conditions, to enable normalization of the data and modelling of the effect of environmental parameters on safety risk. However, normalizing data were limited to those submitted by one of the participating mines. Nevertheless, the design of the data acquisition form was such that the data obtained were already normalized, largely overcoming this potential problem.

Where data was provided in a normalized form, i.e. recorded on the supplementary data acquisition form relative to "Average" or "Normal", the Student t-test was used to determine whether accidents tended to occur under circumstances differing from the average or norm. For the purpose of analysis, numerical values were assigned to the responses as follows:

much less than average/normal = -2;
less than average/normal = -1;
average/normal = 0;
more than average/normal = +1, and
much more than average/normal = +2.

Assigning numerical values to the data made it possible to determine an average response, as well as the standard deviation representing the spread or range of responses. The t-test was then used to assess the significance of any difference between the average value for the responses recorded and the value assumed for the mean of the population of conditions under which accidents occur. For the present analysis, the mean condition was assumed to be 0, i.e. average or normal.

A null hypothesis was then proposed to the effect that "the mean condition under which accidents occur is the average condition" (or the norm, as appropriate). The following symbols are used in describing the mathematical formulation:

μ_0 represents the mean as assumed in the proposed null hypothesis;
$\overline{x}$ represents the observed mean for the responses recorded;
s represents the standard deviation of the responses recorded, and
n represents the number of responses.

The t-statistic was then calculated according to the following relation:

$$t = \frac{(\mu_0 - \overline{x})}{s/\sqrt{n}}$$

where t has n-1 degrees of freedom.

The probability of obtaining the value (or greater) thus calculated for the t-statistic (given the number of degrees of freedom and the null hypothesis being evaluated) was determined by reference to standard statistical tables. Where the probability of obtaining the value calculated is determined to be small, say less than 0,05, the null hypothesis would be rejected, as such a value would indicate the unlikelihood of deriving the observed responses from the distribution of conditions specified in the null hypothesis. The smaller the probability of obtaining the value calculated, the greater the certainty or confidence with which the null hypothesis can be rejected.

Rejection of the null hypothesis (i.e. refuting the assumption that accidents most often happen under average or normal conditions) would be the outcome of a t-test where statistical evidence indicates that the risk of accidents is influenced by the environmental factor being considered, while conversely, the null hypothesis would be accepted where statistical evidence indicates that the environmental factor being considered has no influence on accident rate.

3.2 Safety hazard risk assessments

In order to provide means of looking beyond the immediate causes of accidents and examining the potential for unfavourable environmental conditions to contribute to such occurrences, a series of safety hazard risk assessments based on the System Safety Method was employed *(Stephenson, 1991:77-8)*. These were conducted at three gold and two platinum mines, applying a semi-quantitative technique in which the probability and likely consequences of an event were determined from a scale of options *(Joy, 1995a, b)*. The teams participating in these processes consisted of experienced employees representing a range of job levels within the mining operation.

3.2.1 Approach

A workshop approach was adopted in all instances, during which boundaries, operational sequences, activities and tasks were identified for the specific work process being considered. The processes examined during the safety risk assessments included:

- early and re-entry examinations;
- roof support installation;
- drilling operations;
- cleaning operations, and
- horizontal transport operations.

Once the physical and operational boundaries of the work processes had been defined, their constituent activities and tasks were examined for potential safety hazards. No attempt was made to prejudice the process by identifying a particular type of hazard as a concern, except that, given the focus of the project, only hazards with potential to harm people were evaluated and health hazards were excluded.

3.2.2 Ranking of safety hazards

All relevant hazards were ranked in accordance with the product of their probability of manifesting (1 = high probability and 5 = low probability) and the greatest reasonable consequence of their doing so (1 = fatality and 5 = no injury). Hence, a ranking of 1 would denote a hazard with a high probability of occurring and fatality as its greatest reasonable consequence. Conversely, a ranking of 25 would indicate an unlikely occurrence incapable of causing injury. The probability and consequence scales employed are summarized in Table 3.2.2.

Table 3.2.2

Scales for probability of occurrence and consequence of occurrence used for risk rating

Probable Frequency of Occurrence	Probability/Consequence Ranking	Maximum Reasonable Consequence
Weekly Monthly Yearly 2 to 10-yearly > 10-yearly	12345	Fatality Lost time > 14 days Lost time ≤ 14 days Lost time = 0 days No injury

3.2.3 Analysis of data

A rather simple analysis was applied to the results from the five safety hazard risk assessments, involving the identification of hazards associated with unfavourable environmental conditions and determination of their prevalence, relative to all hazards identified and relative to others linked to the physical environment. Such associations could have been on the basis of a direct causal relationship or an indirect, contributory role.

Analysis was limited, firstly, to hazards with a high risk ranking (1 to 6) and later expanded to consider those with a medium risk ranking (7 to 19). As stated previously, health hazards were excluded, as the focus was on hazards with potential to result in accidents.

The prevalence of high risk safety hazards having an environmental association was determined as a percentage of all safety hazards identified during each of the five risk assessments, as well as by type of mine and then for gold and platinum mines combined.

After the safety hazards with environmental causes or contributors had been identified and their overall prevalences determined, they were analysed to determine relative importance among themselves, i.e. relative to other hazards associated with the environment. At this point the scope was expanded to include medium risk safety hazards along with high risk hazards.

3.3 Employee perception survey

In order to ascertain employees' views regarding the importance of environmental conditions in the occurrence of underground accidents, an employee perception survey was conducted at two large occupational health centres. One of these served six gold mines from one Group, while the second served two platinum mines, also from a single Group.

The decision to conduct the survey at occupational health centres (OHC) was based on the need to obtain input from a large number of employees at various levels, without interfering with their normal duties. Employees are typically required to spend from one to four hours at these centres undergoing their annual medical fitness examinations.

3.3.1 Approach

Project staff members administered the questionnaires, in order to ensure that participants understood the purpose of the survey and to confirm with them the correct procedure for completing the questionnaires. This aspect was addressed by briefing potential participants and affording them ample opportunity to raise questions and concerns. Employees' anonymity was assured and their participation was on a strictly voluntary basis. This approach was seen as essential to ensuring the quality of data obtained.

3.3.2 Questionnaire format

The questionnaire consisted of four pages, the first of which requested background information including:

- present occupation;
- normal workplace;
- experience in present occupation and in mining;
- previous occupations in mining;
- whether a witness to an underground accident and if so, a brief description of the cause, and
- whether injured and if so, a description of the injury.

The second page provided concise instructions for completing the questionnaire, which can be summarized as follows:

- Choose one answer from each pair of possible answers that describes the situation or circumstance more likely to lead to an underground accident;
- Choose only one answer from each pair;
- Do not skip any pairs, and
- Do not spend an excessive amount of time considering the answers, i.e. choose the one that immediately seems more correct.

The next two pages contained 24 pairs of responses (12 pairs per page) to the question, "Accidents are more likely to happen or can happen more easily (when):"

Participants were expected to select one response from each pair by marking the appropriate "tick box".

3.3.3 Questionnaire design

The questionnaire was designed to effect paired comparisons between environmental and four categories of non-environmental issues or factors, in order to determine the overall importance which employees attach to the physical environment within the context of accident occurrence. In addition, the instrument enabled differentiation between the perceived importance of specific aspects of the environment.

The importance of the physical environment was compared with that of non-environmental issues, grouped into the following categories:

- equipment and materials;
- standards and procedures;
- training and competence, and
- management and supervision.

From each of the four categories of non-environmental issues listed above, six responses, each representing a particular issue, were offered within the 24 pairs of possible responses. The non-environmental responses are paraphrased in Table 3.3.3a.

Table 3.3.3a

Non-environmental response statements by category with codes

Non-environmental Category	Response Code	Summary of Response Statement
Equipment & Materials	E&M 1	Machinery giving trouble
	E&M 2	Equipment not properly maintained
	E&M 3	Safety guards absent or inoperative
	E&M 4	Correct equipment or materials not available
	E&M 5	Correct safety/protective equipment unavailable/not used
	E&M 6	Hazardous chemicals or dangerous materials used
Standards & Procedures	S&P 1	Standards impractical or too time-consuming
	S&P 2	Standards require too much work to apply
	S&P 3	Workers don't understand standards or procedures
	S&P 4	Equipment used incorrectly or unsafely
	S&P 5	Work done without using safe work practices
	S&P 6	Standards and safety procedures ignored
Training & Competence	T&C 1	Workers have not had proper training or refreshers
	T&C 2	Workers are new to job or inexperienced
	T&C 3	Workers do not know hazards and how to avoid them
	T&C 4	Workers do not know the task they are busy with
	T&C 5	Workers have been drinking alcohol or smoking dagga
	T&C 6	Workers are sick, unfit or tired

Non-environmental Category	Response Code	Summary of Response Statement
Management & Supervision	M&S 1	Supervisors do not check work and instruct workers
	M&S 2	Supervisors do not check that work is done to standard
	M&S 3	Supervisors have not told workers now to do the job
	M&S 4	Not enough workers to do the job
	M&S 5	Supervisors use inexperienced or untrained workers
	M&S 6	Workers do not understand supervisor's instructions

Each of the non-environmental issues represented in Table 3.3.3a was compared with each of the four environmental issues considered, namely:

- heat;
- visibility;
- noise, and
- ergonomics (representing restricted space and vibration).

The responses representing environmental factors in the questionnaire are presented in Table 3.3.3b.

Table 3.3.3b

Environmental issues and representative response statements from the questionnaire

Environmental Issue	Response Statement from Questionnaire
Heat	When the workplace is too hot.
Visibility	When it is difficult to see, because it is too dark or there is too much dust or fog.
Noise	When there is too much noise for people to communicate or hear warning signals.
Confined space	When there is not enough space or room to work.
Vibration	When machinery shakes too much making it difficult to control.

3.3.4 Questionnaire variants

In order to provide for multiple and varied comparisons between environmental and non-environmental issues, four different variants of the questionnaire were formulated. In addition to maximizing the variety or number of comparisons between environmental and non-environmental factors, multiple variants allowed the page positions (left vs. right) of the responses to be varied from one variant to the next. The intention here was to minimize the negative effects of any "mechanical" approach that participants might adopt in completing the questionnaires, i.e. selecting only those responses on the left or right side of the page or alternating sides from one pair to the next without regard to the content of the responses offered.

The pairings of environmental and non-environmental responses with their respective page positions for each of the four questionnaire variants are presented in Table 3.3.4.

Equal numbers of the four questionnaire variants were printed and efforts made to issue similar numbers of each among participants. The purpose was to ensure varied comparisons of the issues considered, so as to enable the measurement of each environmental issue's importance in comparison with multiple non-environmental issues.

Table 3.3.4

Combinations of paired responses and page positions for the four variants of questionnaire

Question No.	Variant 1		Variant 2		Variant 3		Variant 4	
	Left	Right	Left	Right	Left	Right	Left	Right
1	Heat	E&M 5	Noise	M&S 5	M&S 5	Visibility	M&S 5	Vibration
2	T&C 4	Confined space	Heat	T&C 4	Noise	T&C 4	T&C 4	Visibility
3	S&P 3	Vibration	Heat	S&P 3	Noise	S&P 3	S&P 3	Visibility
4	E&M 2	Heat	E&M 2	Noise	Confined space	E&M 2	Visibility	E&M 2
5	M&S 1	Noise	Confined space	M&S 1	Visibility	M&S 1	M&S 1	Heat
6	Noise	S&P 6	S&P 6	Visibility	S&P 6	Confined space	Heat	S&P 6
7	E&M 5	Visibility	E&M 5	Vibration	Heat	E&M 5	Noise	E&M 5
8	Confined space	M&S 4	Visibility	M&S 4	M&S 4	Heat	M&S 4	Noise
9	Visibility	T&C 3	T&C 3	Heat	T&C 3	Noise	Confined space	T&C 3
10	S&P 2	Heat	S&P 2	Noise	Confined space	S&P 2	Visibility	S&P 2
11	Heat	E&M 1	Noise	E&M 1	E&M 1	Visibility	E&M 1	Confined space
12	Noise	T&C 6	T&C 6	Visibility	T&C 6	Vibration	Heat	T&C 6
13	Vibration	S&P 5	Visibility	S&P 5	S&P 5	Heat	S&P 5	Noise
14	E&M 4	Noise	Vibration	E&M 4	Visibility	E&M 4	E&M 4	Heat
15	M&S 3	Visibility	M&S 3	Confined space	Heat	M&S 3	Noise	M&S 3
16	T&C 2	Heat	T&C 2	Noise	Vibration	T&C 2	Visibility	T&C 2
17	S&P 1	Visibility	Noise	S&P 1	Heat	S&P 1	S&P 1	Vibration
18	Noise	M&S 6	Heat	M&S 6	M&S 6	Vibration	M&S 6	Visibility
19	Heat	T&C 5	T&C 5	Vibration	T&C 5	Visibility	Noise	T&C 5
20	S&P 4	Noise	Confined space	S&P 4	Visibility	S&P 4	S&P 4	Heat
21	Visibility	E&M 3	E&M 3	Heat	E&M 3	Noise	Confined space	E&M 3
22	Visibility	M&S 2	M&S 2	Heat	M&S 2	Noise	Vibration	M&S 2
23	Confined space	T&C 1	Visibility	T&C 1	T&C 1	Heat	T&C 1	Noise
24	E&M 6	Vibration	E&M 6	Visibility	Noise	E&M 6	Heat	E&M 6

3.3.5 Questionnaire language versions

In order to ensure accuracy in assessing employees' perceptions, it was necessary to make the questionnaires accessible to respondents representing a range of language groups. Accordingly, and after consulting with mine personnel regarding language preferences, the instrument was translated into six additional languages from the original English.

The seven resulting language versions were:

- i) English;
- ii) Afrikaans;
- iii) North Sotho;
- iv) South Sotho;
- v) Tswana;
- vi) Xhosa, and
- vii) Zulu.

The four variants of the questionnaire and the seven languages employed resulted in a total of 28 versions of the instrument. Questionnaire variant No. 1 is appended for all language versions (Appendix 2).

Participants were offered a choice of questionnaires from the seven languages available.

3.3.6 Questionnaire administration

Underground employees were identified at the OHCs' reception points and, with the assistance of OHC personnel, screened for functional literacy, either on the basis of education (minimum of Standard 4) or a brief interview. Suitable individuals were provided with an explanation of the purpose of the survey and given the opportunity to accept or decline participation.

Some employees willing to participate were found to lack the requisite reading skills to interpret the questionnaire and express their views. Where a small number of such individuals was present, assistance was provided by project staff members or, in some instances, by OHC personnel. Where large numbers of participants required assistance, they were put into groups of 20 to 25 individuals and all issued the same variant of the questionnaire (generally irrespective of language, owing to its irrelevance in the presence of literacy problems).

Researchers then provided the group with a verbal explanation of the available responses, one pair at a time. This assisted all members of the group in gaining an understanding of each response to be able to make their selections individually. The relative merits and veracity of the responses offered were not discussed, as to do so could have influenced participants' choices.

Each time a group was assisted in the manner described above, a different variant of the questionnaire was employed, in order to maintain parity of numbers among the four variants that were completed and, thus, the intended variation in comparisons made.

3.3.7 Analysis of data

The analysis of results from the employee perception survey involved an overall analysis of the perceived importance of environmental factors, as well as the partitioning of data into various sub-sets. These included type of mine, workplace and occupational/departmental groupings, as well as job level and experience in mining.

Owing to the design of the questionnaire and its use of paired comparisons between environmental and non-environmental factors, the chi-squared (X^2) test was deemed the most appropriate means of analysis and validation. This statistical tool was applied in evaluating respondents' selection of environmental over non-environmental factors, as well as in assessing the reliability of the data as a source of information on employees' perceived importance of the environment in accident occurrences.

The χ^2 test was used to compare the observed set of responses with the set which would be expected according to the null hypothesis being evaluated. A typical null hypothesis would be that respondents' selection of the environmental factor over the non-environmental factor is independent of a third variable such as type of mine, job level, age/experience of the respondent or which environmental factor is considered. Of the number of responses (N_i) where the third variable was in state "i", the observed number of responses selecting the environmental factor (O_i) was derived directly from the questionnaires. The number of responses expected to select the environmental factor according to the null hypothesis would be denoted as E_i, which was calculated as follows:

$$E_i = \left(\sum_{i=1}^{n} O_i \Big/ \sum_{i=1}^{n} N_i \right) \times N_i$$

The χ^2 statistic is then computed as $\sum_{i=1}^{n} \left[(O_i - E_i)^2 / E_i \right]$, with n-1 degrees of freedom.

The probability of obtaining the value (or greater) thus calculated for the χ^2 statistic (given the number of degrees of freedom and the null hypothesis being evaluated) was determined by reference to standard statistical tables. Where the probability of obtaining the value calculated is small, say less than 0,05, the null hypothesis would be rejected, as such an outcome would indicate the unlikelihood of deriving the observed responses from the distribution specified in the null hypothesis. The smaller the probability of obtaining the value calculated, the greater is the certainty or confidence with which the null hypothesis can be rejected.

Rejection of the null hypothesis (i.e. refuting the assumption that selection of the environmental factor over the non-environmental factor is independent of other variables being considered) would be the outcome of a χ^2 test where statistical evidence indicates a different probability of selecting the environmental factor for responses with different values for the "third variable" (as defined above). When the third variable refers to which of the various environmental factors is being considered, then rejection of the null hypothesis would be the outcome where statistical evidence indicates different levels of perceived importance for the various environmental factors examined.

4 Results and discussion

The results from each of the three sources of data employed are presented in their respective subsections which follow, along with discussion thereof.

4.1 Accident investigations

Data was obtained on a total of 369 accidents to quantify the environmental conditions under which accidents occurred. The final version of the supplementary data acquisition form (Appendix 1) was used by participating mines to record the information. Data was gathered from eight mines of which six were gold mines and two were platinum producers. Table 4.1a provides the number of accident reports obtained from each mine, with a code having been assigned where "G" indicates a gold mine and "P" indicates platinum.

Table 4.1a

Number of accidents reported from each participating mine

Mine	No. of accidents
G1	29
G2	20
G3	60
G4	29
G5	70
G6	74
Sub-total gold	282
P1	22
P2	65
Sub-total platinum	87
Total	369

On the data acquisition forms, information was recorded on the major environmental factors which may influence the occurrence of accidents, i.e. heat stress, visibility, noise and ergonomics, the last including both vibration and confined working space. Results of the data analysis are presented under these four major sub-headings.

4.1.1 Heat stress

Figure 4.1.1a provides the distribution of normal heat stresses in the workplaces where accidents took place compared with the average on the mine for that type of workplace.

The results obtained show a dominance of the response, "Average". "Lower than average" was found to occur slightly more frequently than "Higher than average".

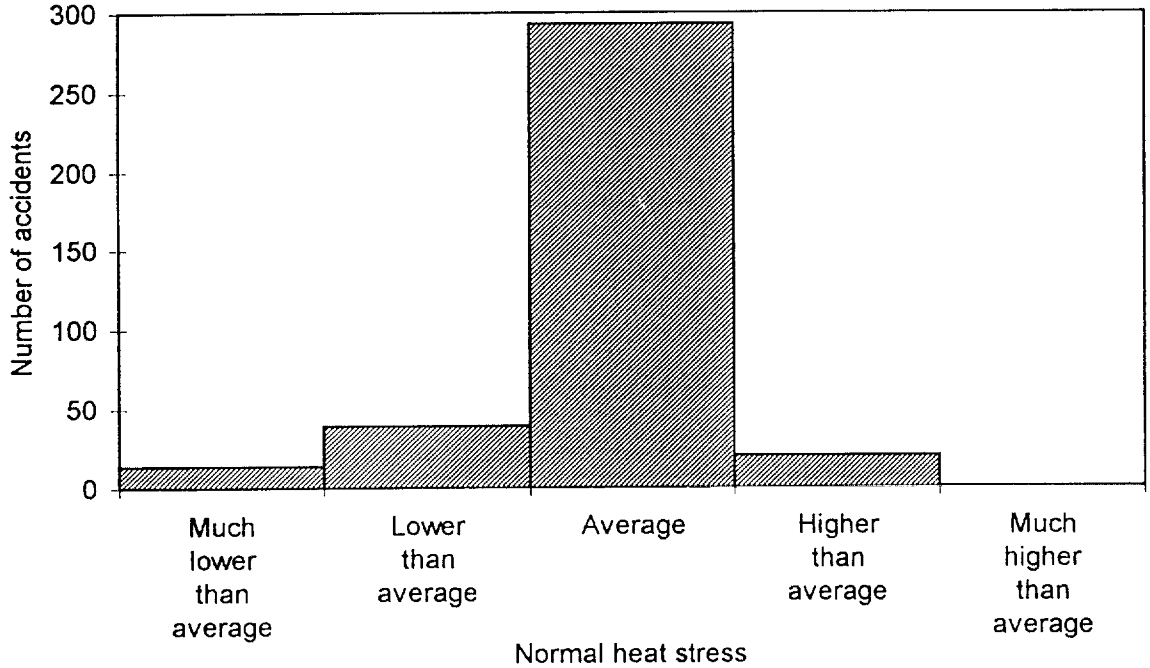

Figure 4.1.1a Distribution of accidents in relation to normal heat stress at accident site

Table 4.1.1a provides summary statistics for the normal heat stress at accident locations compared with the average for that type of work place on the mine. The statistics were calculated by assigning a value of 0 to a response of average with -1 being assigned to lower than average, -2 to much lower than average, +1 to higher than average and +2 to much higher than average. The data is provided for each mine, for both commodities or types of mine and for all mines participating. The standard deviations represent the spread for the distributions of responses, with the standard error being the error associated with determination of the mean of the distribution, calculated as the standard deviation divided by the square root of the number of accidents. The t statistic is an indicator of whether or not there is a deviation of the responses from average, and is drawn from a Student's t distribution with degrees of freedom equal to the number of accidents minus 1.

The results presented in Table 4.1.1a indicate that overall and on gold mines, there is evidence that accidents occur with greater frequency in work places with heat stresses lower than average for that type of work place. The same conclusion applies to mines G3 and P1. However, it should be noted that, although statistically significant, the departure from average is not large as a result of the preponderance of "Average" responses.

Table 4.1.1a

Summary statistics for normal heat stress in workplace compared with average for that type of workplace on the mine

Mine/ commodity	Number of accidents	Average	Standard deviation	Standard error	t-statistic
G1	29	-3	50	93	-37
G2	20	-1	64	143	-70
G3	60	-45	83	107	-419
G4	29	-3	42	78	-44
G5	70	-9	63	75	-114
G6	74	0	0	0	-
Gold	282	-13	58	35	-377
P1	22	-27	55	117	-232
P2	63	-3	40	50	-63
Platinum	85	-9	45	49	-191
Total	367	-12	56	29	-422

Figures 4.1.1b, 4.1.1c, 4.1.1d, 4.1.1e and 4.1.1f provide environmental survey results of the heat related environmental conditions in the work places where accidents took place.The survey results reflect the normal conditions in the work places, owing to the impossibility of obtaining measurements of actual conditions at the time of occurrence. Accordingly, mines were requested to supply the results of the environmental survey performed closest to the date of the accident. It was considered that this would be at least as representative and possibly more representative of the conditions as a special survey performed immediately after the accident would be.

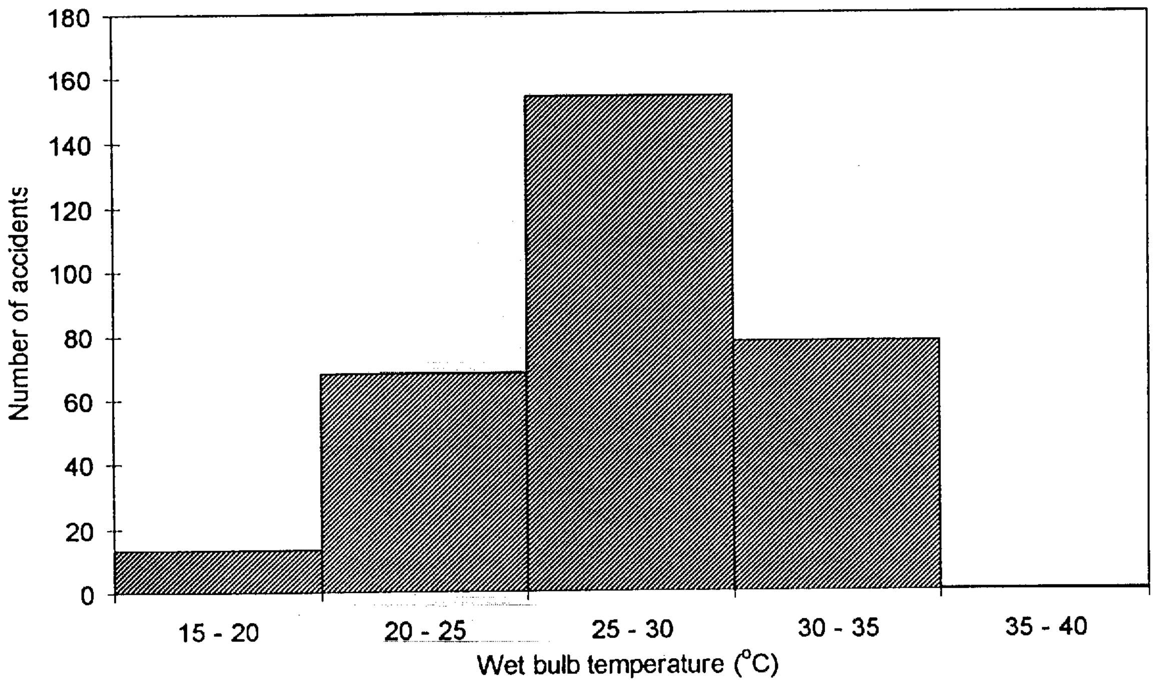

Figure 4.1.1b Distribution of accidents in relation to wet bulb temperature

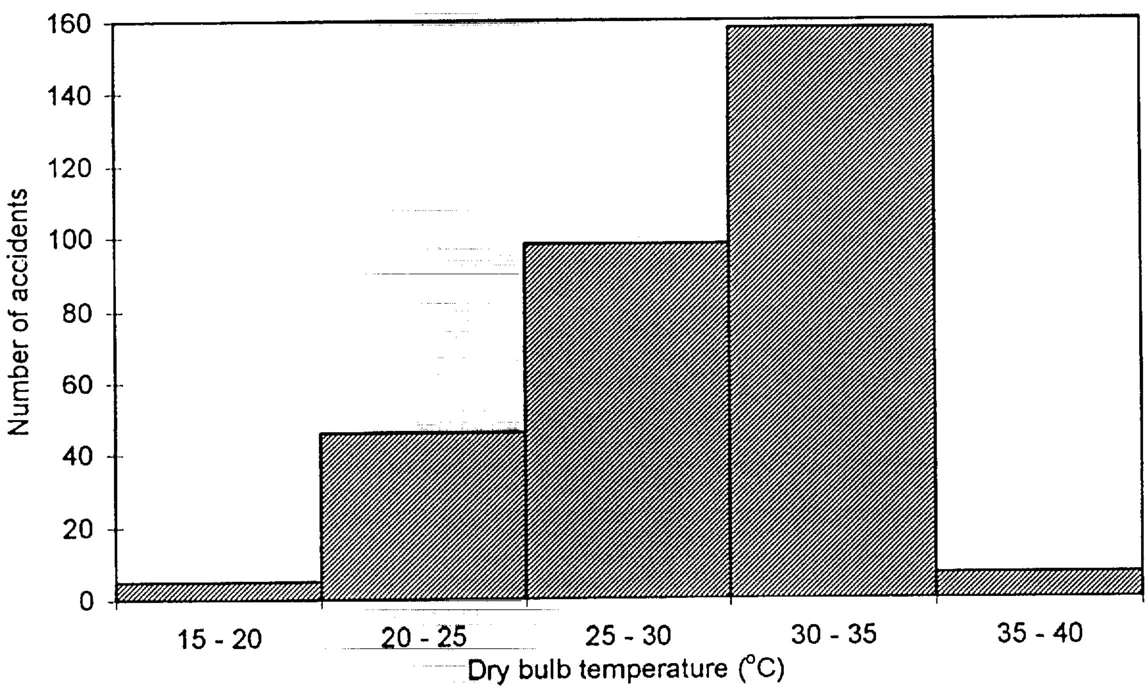

Figure 4.1.1c Distribution of accidents in relation to dry bulb temperature

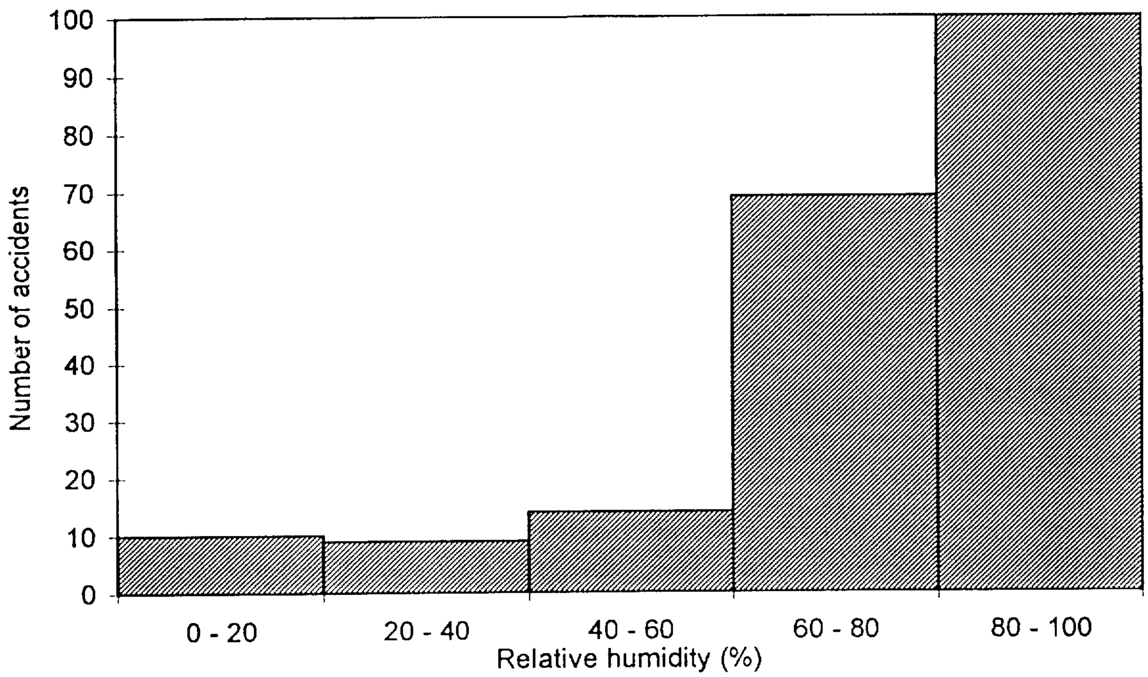

Figure 4.1.1d Distribution of accidents in relation to relative humidity

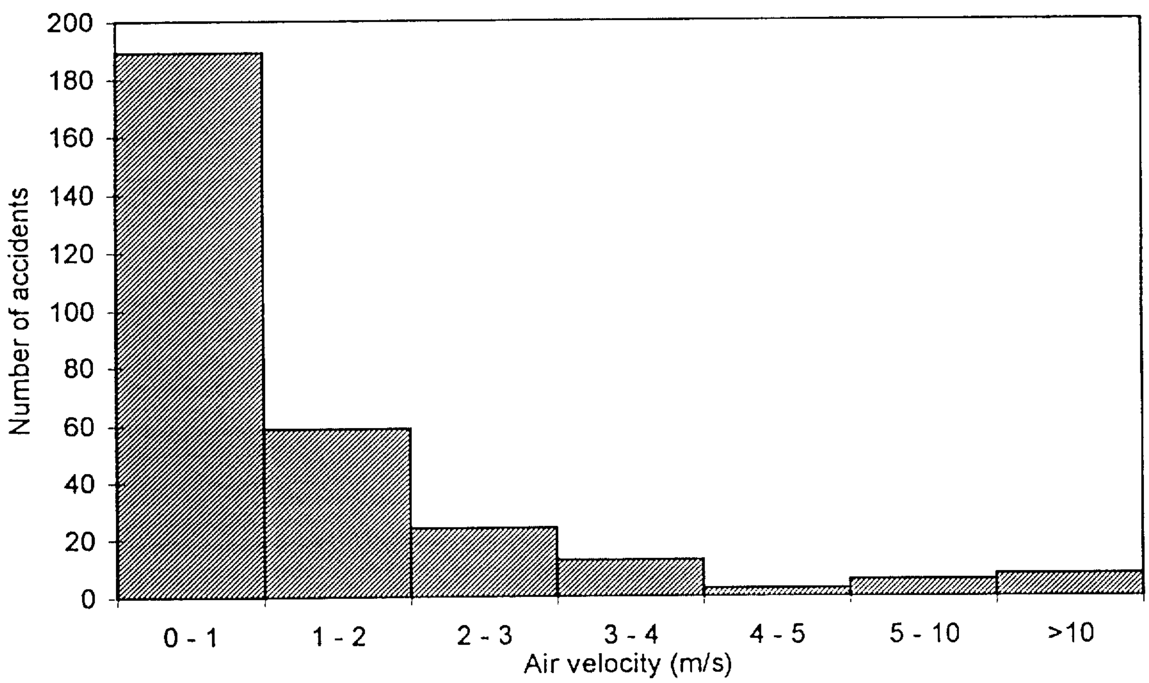

Figure 4.1.1e Distribution of accidents in relation to air velocity

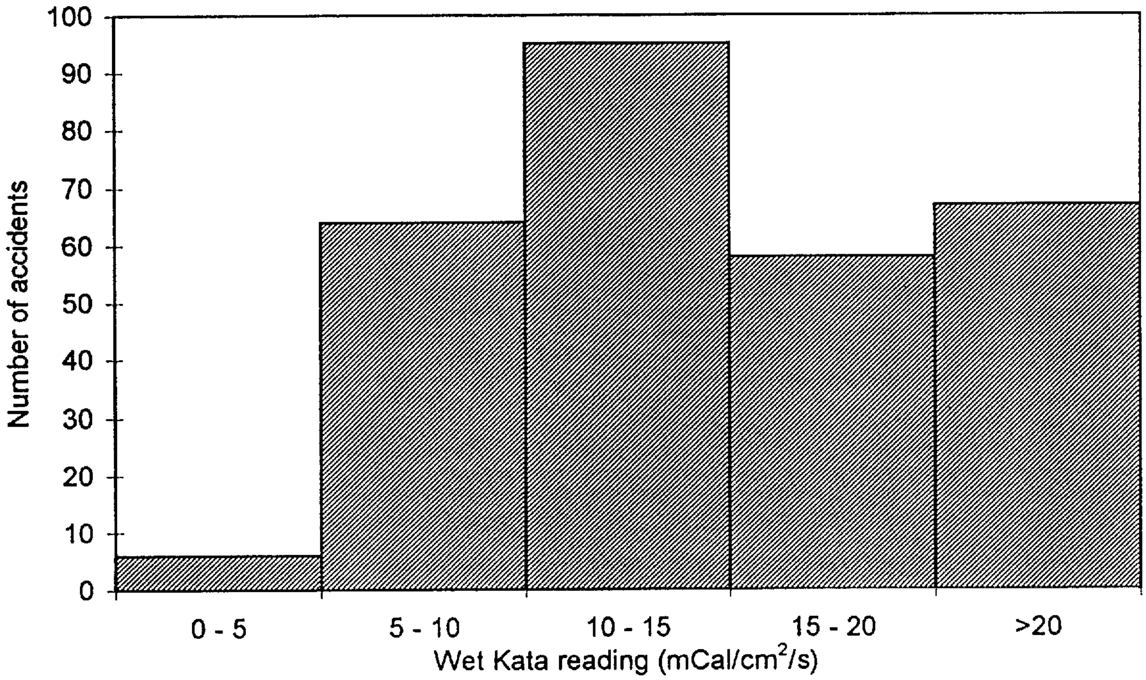

Figure 4.1.1f Distribution of accidents in relation to wet Kata reading

The environmental conditions displayed in Figures 4.1.1b, c, d, e and f appear to reflect a typical distribution of environmental conditions which would be experienced in a deep level South African hard rock mine. In particular, a relative absence of wet bulb temperatures greater than 32°C, wet Kata readings less than 5 and air velocities less than 1 m/s is noted. This is indicative of accident rates not being greater per man hour of exposure to adverse heat related environmental conditions. However, it should be noted that the lack of normalization data prevents a reliable assessment of how risk per man hour worked, per centare mined or per ton mined depends on the environmental variables recorded. Only one of the mines, G2, submitted information summarizing the number of development ends and stope face panels falling in coarse wet bulb temperature and wet Kata reading ranges. Since this mine only had 20 accidents investigated for environmental conditions, the sample for this aspect of the heat stress indicators was statistically insufficient to permit the establishment of meaningful relationships between safety risk and these heat parameters.

Figure 4.1.1g provides the distribution of heat stresses at the time of the accident compared with the norm for that workplace. Again, a dominance of the response "Normal" is observed, with the response "Lower than normal" attracting a greater number of responses than "Higher than normal".

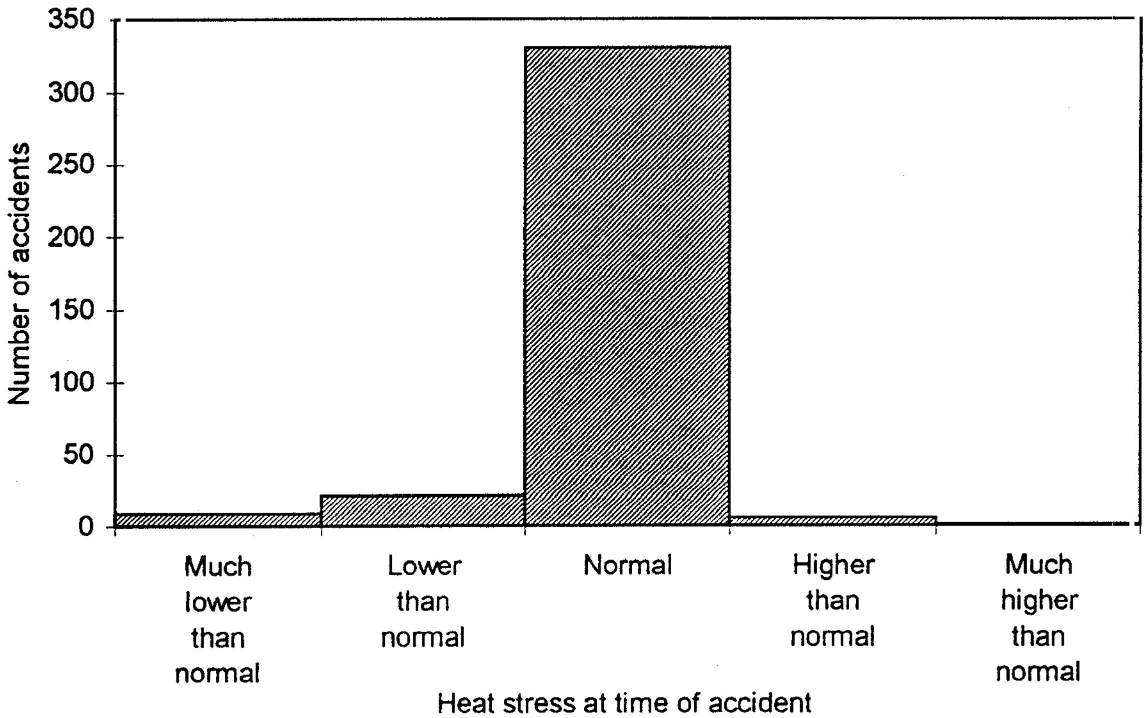

Figure 4.1.1g Distribution of accidents in relation to heat stress at time of accident compared with norm for workplace

Table 4.1.1b

Summary statistics for heat stress at time of accident compared with norm for that workplace

Type of Mine	Number	Average	Std. dev.	Std. error	t-statistic
G1	29	0,03	0,19	0,034	1,00
G2	20	-0,15	0,49	0,109	-1,37
G3	60	-0,37	0,74	0,095	-3,86
G4	29	0,00	0,00	0,000	-
G5	70	-0,10	0,46	0,054	-1,84
G6	74	0,00	0,00	0,000	-
Gold	282	-0,11	0,45	0,027	-4,08
P1	22	-0,09	0,29	0,063	-1,45
P2	63	0,03	0,25	0,032	1,00
Platinum	85	0,00	0,27	0,029	0,00
Total	367	-0,08	0,42	0,022	-3,86

Table 4.1.1b provides summary statistics for this variable calculated on a similar basis to the statistics provided in Table 4.1.1a. Again, the analysis indicates that the frequency of accidents is greater when the heat stress is below the norm for that workplace, for the entire dataset, for the participating gold mines and for mine G3. However, as reported previously, the magnitude of the effect is relatively small even though it is statistically significant due to the preponderance of "Normal" responses.

The distribution of change in heat stress immediately prior to an accident is provided in Figure 4.1.1h. It is evident that a change in heat stress was almost never identified.

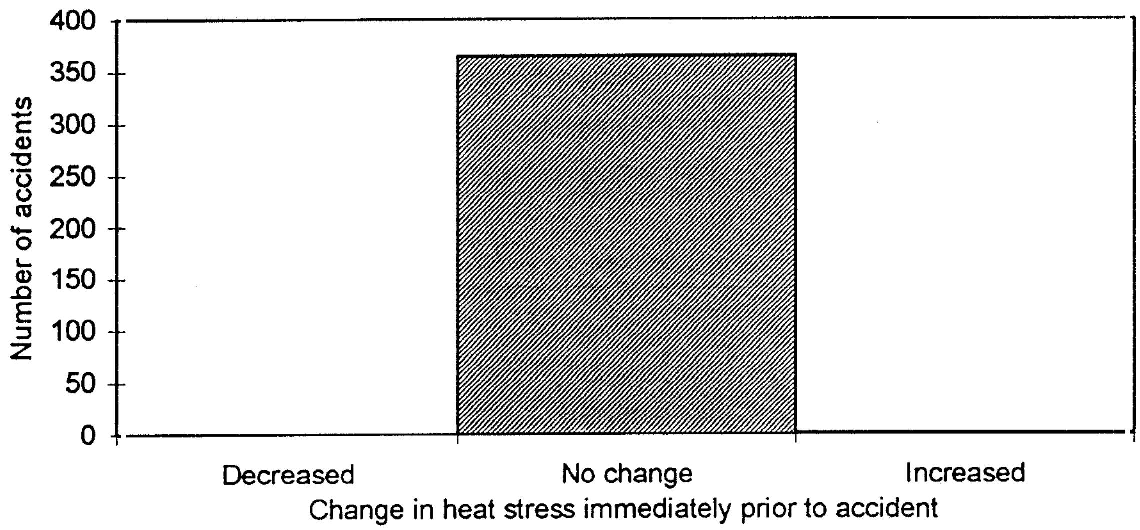

Figure 4.1.1h Distribution of accidents in relation to changes in heat stress immediately prior to occurrence

Figure 4.1.1i provides information on the availability of drinking water at accident locations. It is apparent that in the majority of cases, drinking water was available, both normally and at the time of the accident, although the distance of the drinking water supply from the work place was evenly distributed over the three distance categories, viz. <50 m, 50-100 m and >100 m. In most cases, adequate drinking water had been drunk by the mineworker involved in the accident prior to the accident taking place.

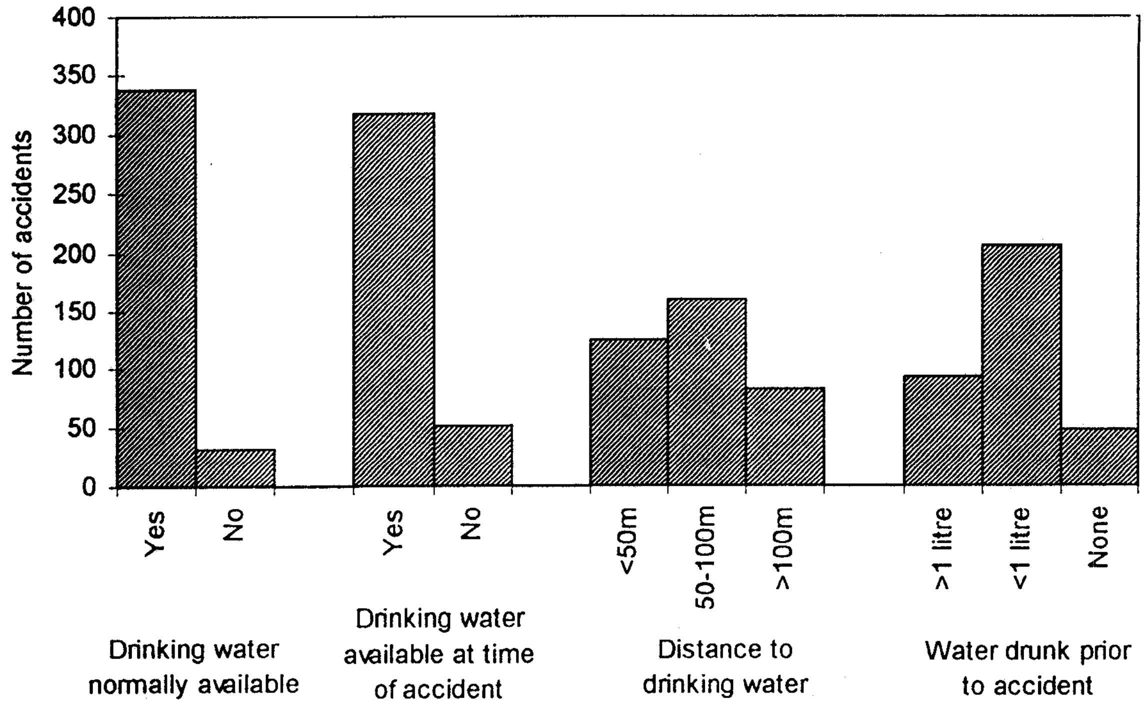

Figure 4.1.1i Distribution of accidents in relation to drinking water availability

An additional analysis considering the amount of water drunk prior to the accident in association with the amount of time worked during the shift prior to the accident occurrence revealed no correlation between these two variables.

Figure 4.1.1j provides the distribution of physical exertion prior to the accident as compared with normal for the worker or workers involved in causing the accident. Again, the predominant response was "Normal". There was a slight preference for responses indicating "Less than normal" over "Greater than normal". This finding is confirmed in Table 4.1.1c where the indication is that accidents take place more frequently when physical exertion is less than normal. This finding applies on an overall basis, to gold mines and on mine G2 in particular and is more likely an indication of how the data capture forms were completed than of what the levels of exertion were prior to accidents.

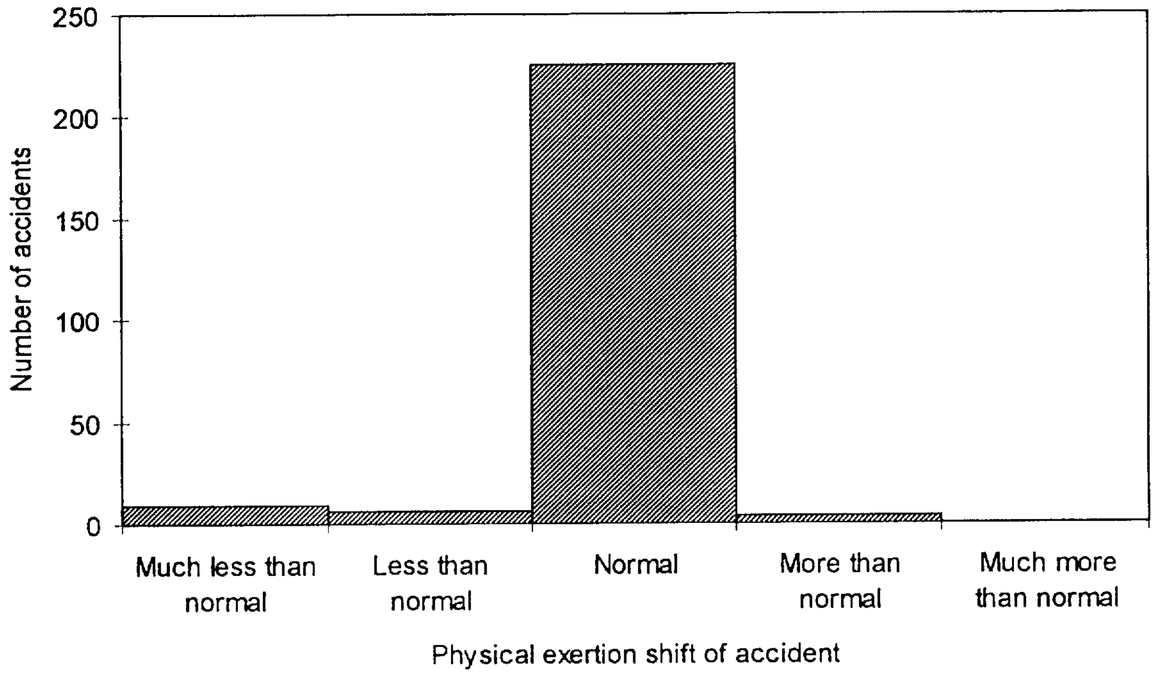

Figure 4.1.1j Distribution of accidents in relation to physical exertion prior to occurrence

Table 4.1.1c

Summary statistics for physical exertion prior to accident compared with normal for that mineworker

Mine/ commodity	Number	Average	Standard deviation	Standard error	t-statistic
G1	29	-0,03	0,19	0,034	-1,00
G2	20	-0,80	1,11	0,247	-3,24
G3	36	-0,03	0,29	0,049	-0,57
G4	30	0,03	0,18	0,033	1,00
G5	67	0,03	0,24	0,030	1,00
G6	34	0	0,00	0,000	-
Gold	216	-0,07	0,45	0,031	-2,26
P1	19	-0,11	0,46	0,105	-1,00
P2	10	-0,10	0,32	0,100	-1,00
Platinum	29	-0,10	0,41	0,076	-1,36
Total	245	-0,07	0,45	0,029	-2,57

Figures 4.1.1k and 4.1.1l display the heat tolerance testing and screening results for those mineworkers identified as involved in causing accidents. Again, without normalization data for the distribution of heat tolerance results for the overall population of mineworkers on the mines considered in the study, it is not possible to state definitively whether risk is influenced by heat tolerance. However, the distributions do not appear to suggest that there is any evidence for heat intolerant mineworkers being more likely to be involved in accidents.

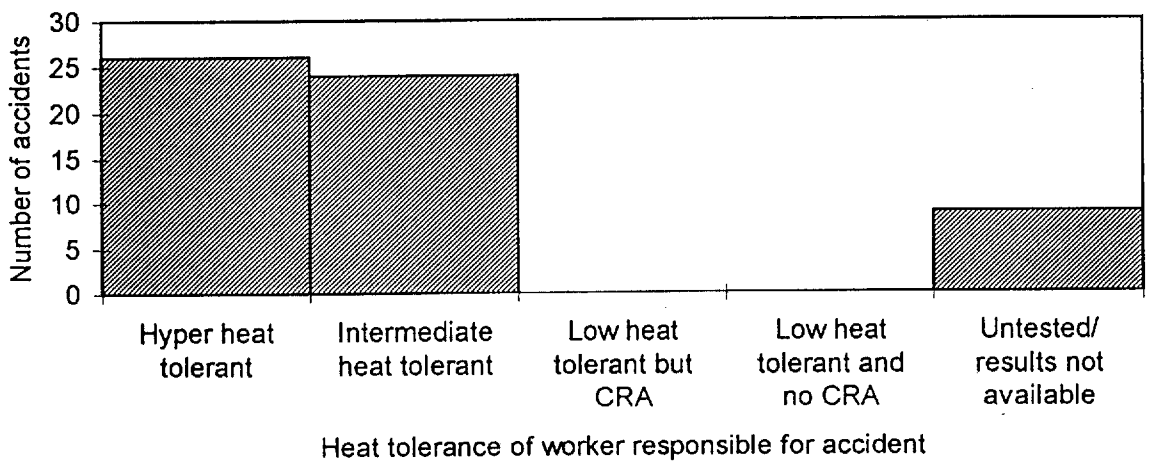

Figure 4.1.1k Distribution of accidents in relation to heat tolerance test results for workers associated with occurrences

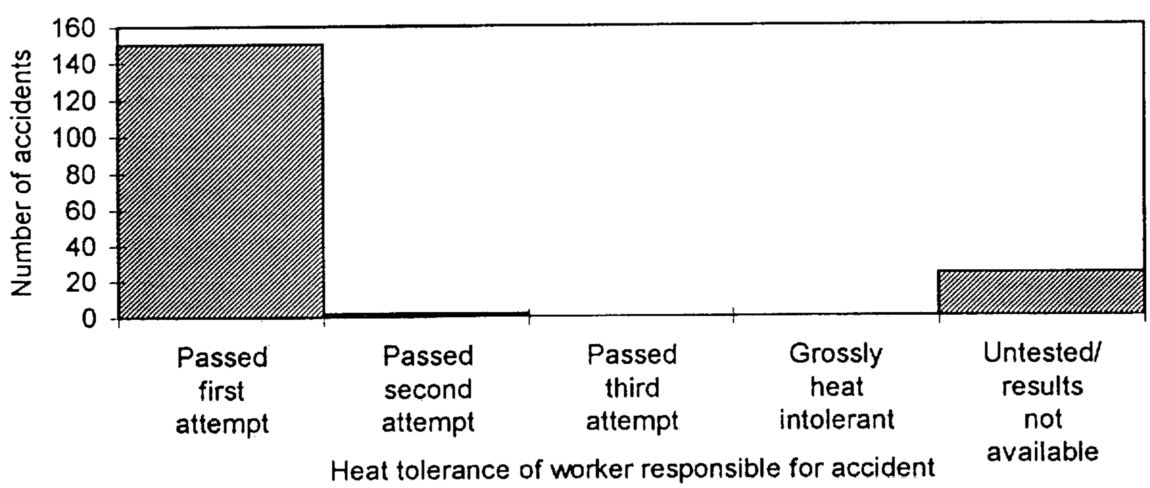

Figure 4.1.1l Distribution of accidents in relation to heat tolerance screening results for workers associated with occurrences

4.1.2 Visibility factors

Figure 4.1.2a provides the distribution for the visibility normally experienced in work places where accidents took place, as compared with the average for that type of work place on the mine. Again, there is a preponderance of the response "Average", with "Greater than average" visibility being quoted slightly more frequently than "Less than average" visibility.

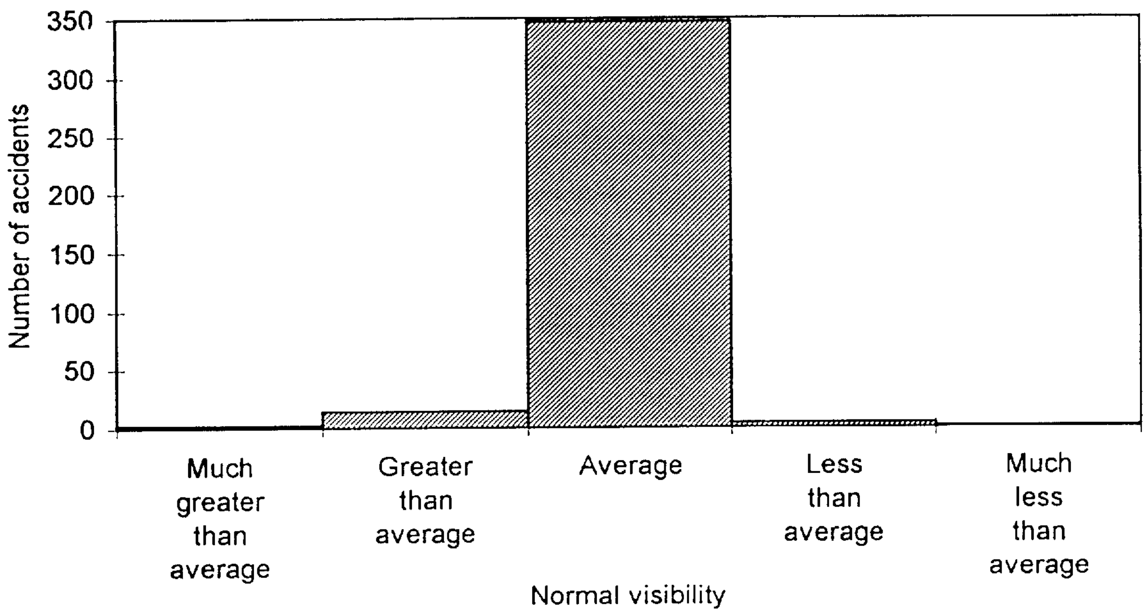

Figure 4.1.2a Distribution of accidents in relation to normal visibility at accident sites

Table 4.1.2a shows that, on an overall basis and for the gold mines included in the study, there is statistical evidence that accidents tend to occur more frequently in workplaces where the visibility is better than average. This is based on the value of the t statistic which has the number of degrees of freedom as defined in the discussion of Table 4.1.1a. However, because in only 6 per cent of cases was a response other than "Average" selected, the effect is extremely small in magnitude and, again, more likely an indication of the manner in which the data capture forms were completed than of conditions at the time of accidents.

Table 4.1.2a

Summary statistics for normal visibility in workplace compared with average for that type of workplace on the mine

Mine/ commodity	Number	Average	Standard deviation	Standard error	t-statistic
G1	29	-0,07	0,26	0,048	-1,44
G2	20	-0,05	0,39	0,088	-0,57
G3	59	-0,08	0,34	0,044	-1,93
G4	29	-0,03	0,19	0,034	-1,00
G5	70	-0,01	0,47	0,056	-0,26
G6	74	-0,01	0,12	0,014	-1,00
Gold	281	-0,04	0,32	0,019	-2,05
P1	22	-0,05	0,21	0,045	-1,00
P2	65	0	0,00	0,000	-
Platinum	87	-0,01	0,11	0,011	-1,00
Total	368	-0,03	0,28	0,015	-2,20

Figure 4.1.2b and Table 4.1.2b show a similar perspective with regard to illumination level, with approximately equal contributions from "Brighter than average" and "Dimmer than average" with a predominance of "Average".

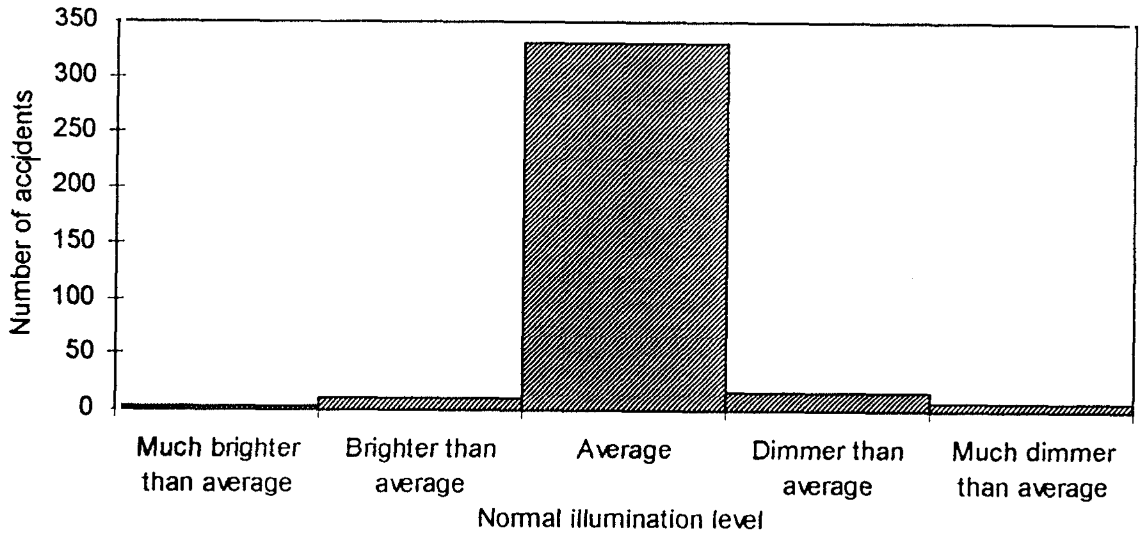

Figure 4.1.2b Distribution of accidents in relation to normal illumination at accident sites

Table 4.1.2b

Summary statistics for normal illumination levels at accident site as compared with average for that type of workplace on the mine

Mine/ commodity	Number	Average	Standard deviation	Standard error	t-statistic
G1	29	0	0,27	0,050	0,00
G2	20	0	0,00	0,000	-
G3	60	0,12	0,76	0,098	1,19
G4	29	-0,03	0,19	0,034	-1,00
G5	70	0,09	0,58	0,070	1,23
G6	74	-0,01	0,12	0,014	-1,00
Gold	282	0,04	0,47	0,028	1,39
P1	22	0	0,00	0	-
P2	65	0,02	0,28	0,035	0,44
Platinum	87	0,01	0,24	0,026	0,45
Total	369	0,03	0,43	0,022	1,46

In Figure 4.1.2c, the normal levels of noticeable dust and noticeable diesel emissions are presented in comparison with the average for work places of the type where the accident took place. Again, an "Average" response predominates for both variables with "Less than average" and "Much less than average" being selected occasionally. This again leads to the implication that accidents are more likely where conditions are more favourable, in this instance, when noticeable dust or noticeable diesel emissions are less than average.

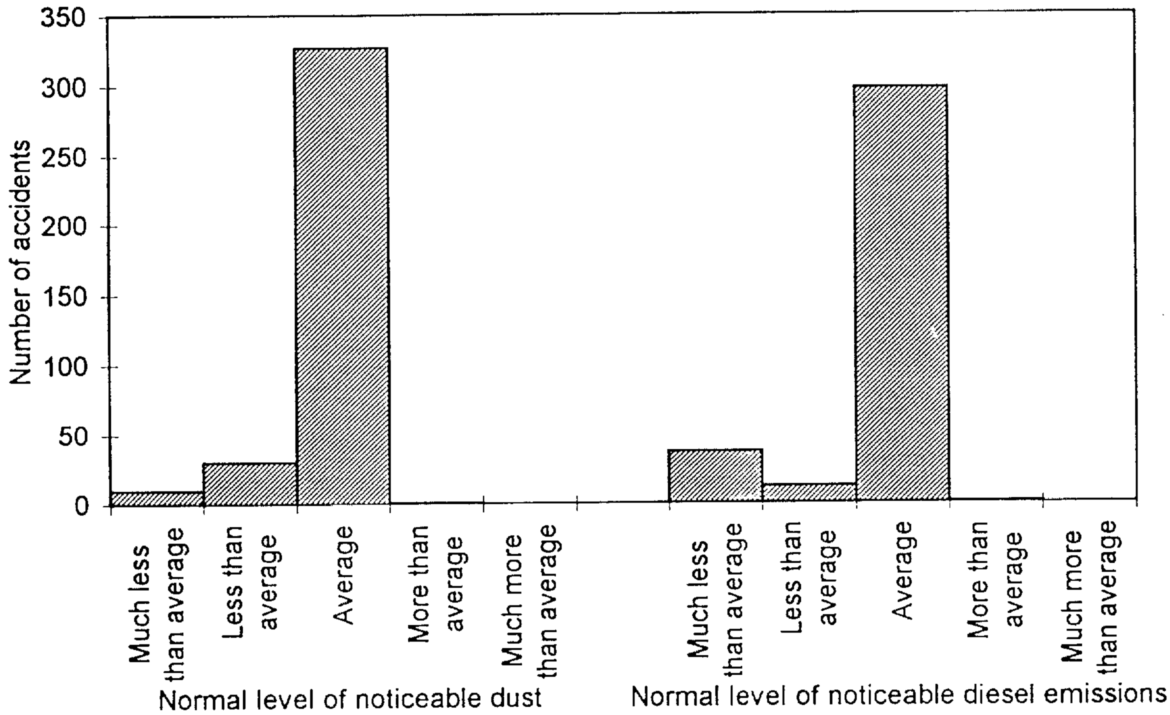

Figure 4.1.2c Distribution of accidents in relation to normal particulate levels at accident sites

Figures 4.1.2d and 4.1.2e provide the distributions of illuminance levels and dust levels according to surveys conducted closest to the time of the accident. As for heat stress, special surveys were not undertaken immediately after the accident to more accurately quantify the conditions at the time of occurrence, as this is likely to lead to unrepresentative samples. The distribution of dust levels is considered to be unusually high, in that a dust level in excess of 2 mg/m^3 is beyond typically acceptable limits on gold and platinum mines.

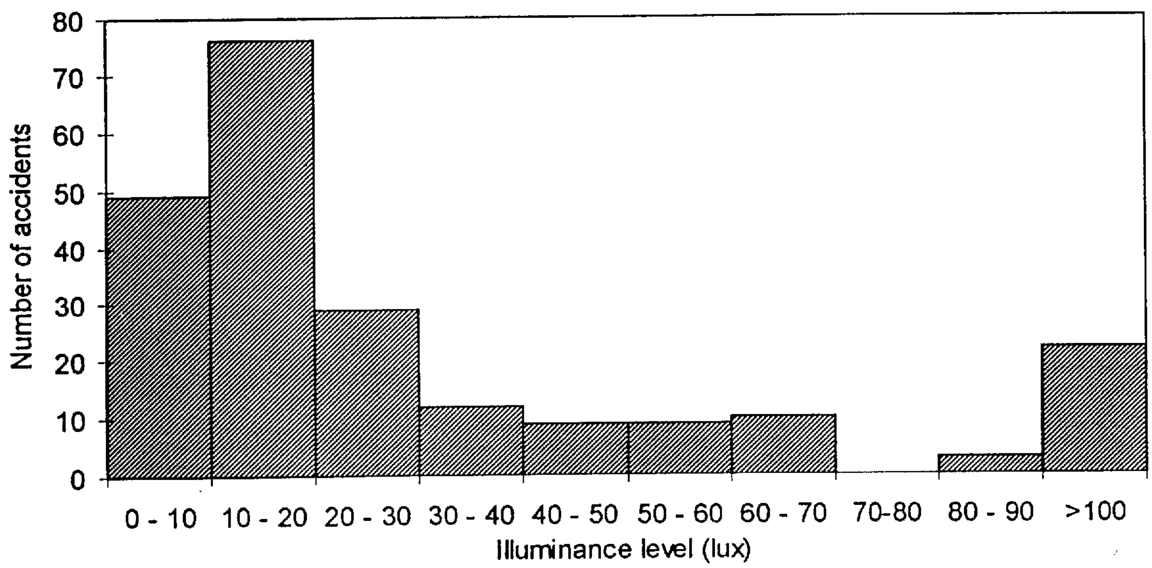

Figure 4.1.2d Distribution of accidents in relation to illuminance level at time of occurrence

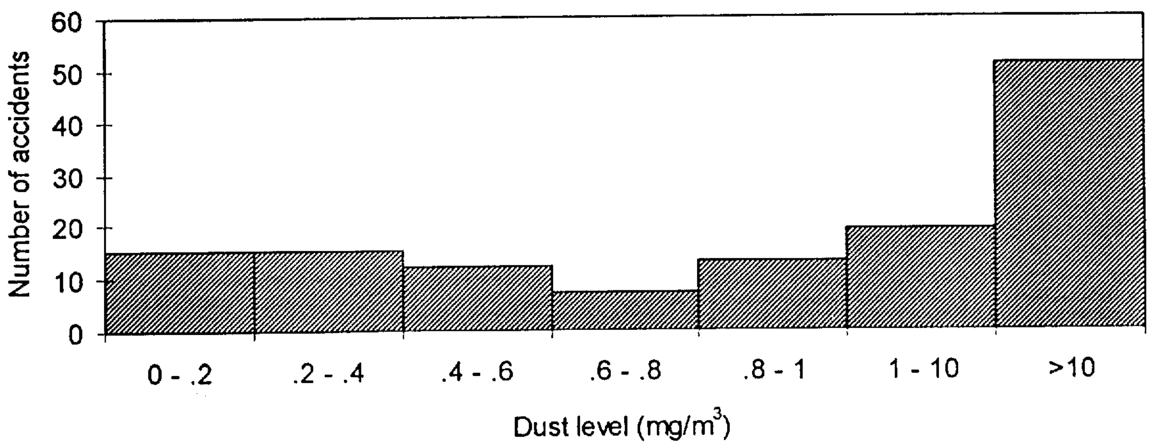

Figure 4.1.2e Distribution of accidents in relation to normal dust levels where accidents occurred

Figure 4.1.2f shows that only on few occasions, being 4 per cent of the total, was a departure from normal visibility identified at the time of the accident compared with the norm for the work place. This is confirmed in Table 4.1.2c where no statistically significant departures from the "Average" response are observed. For this variable, the small number of deviations are to either side of average.

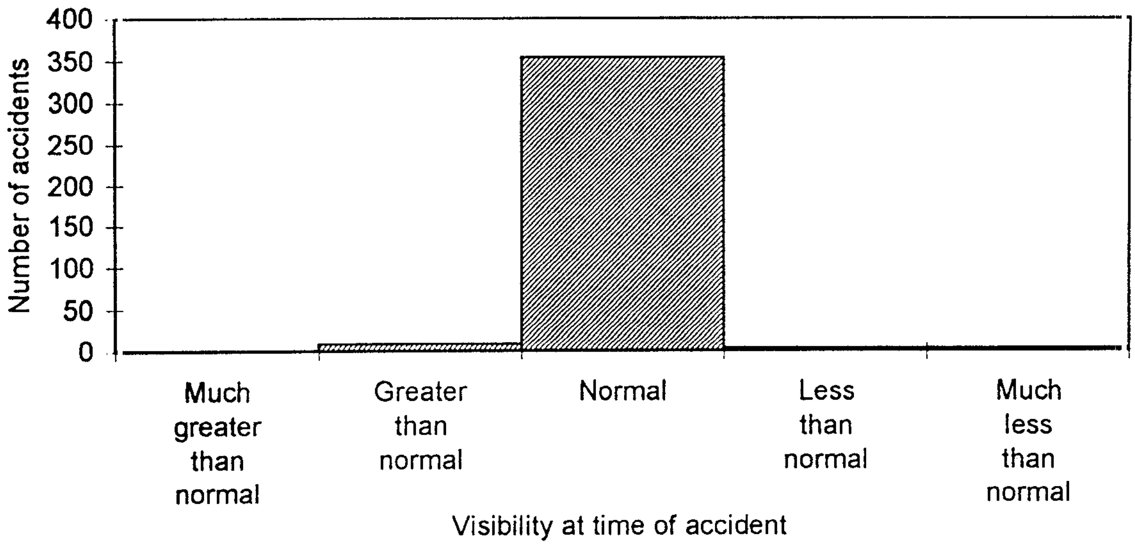

Figure 4.1.2f ***Distribution of accidents in relation to visibility at time of occurrence compared with norm for workplace***

Table 4.1.2c

Summary statistics for visibility at time of accident compared with norm for that workplace

Mine/ commodity	Number	Average	Standard deviation	Standard error	t-statistic
G1	29	0,03	0,42	0,078	0,44
G2	20	0	0,00	0,000	-
G3	60	-0,03	0,26	0,033	-1,00
G4	29	0	0,00	0,000	-
G5	70	0	0,48	0,058	0,00
G6	74	-0,01	0,12	0,014	-1,00
Gold	282	-0,01	0,30	0,018	-0,39
P1	22	-0,05	0,21	0,045	-1,00
P2	65	0,02	0,12	0,015	1,00
Platinum	87	0	0,15	0,016	0,00
Total	369	-0,01	0,28	0,014	-0,38

Similarly, Figure 4.1.2g shows that almost never was an accident immediately preceded by a change in the visibility conditions.

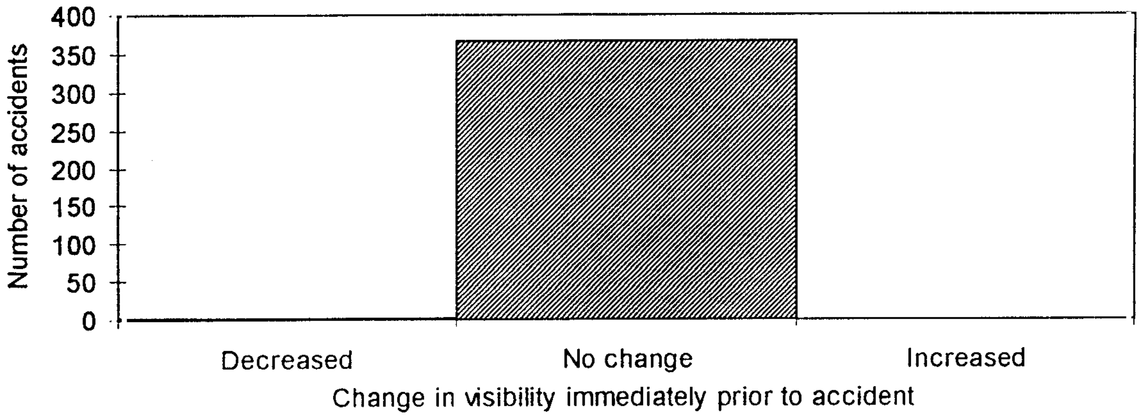

Figure 4.1.2g Distribution of accidents in relation to changes in visibility immediately prior to occurrence

Figure 4.1.2h illustrates responses concerning the use of eye protection by the mineworkers involved in the accidents considered. In approximately 77 per cent of cases eye protection was not used, but only rarely was it considered that its use or lack thereof was a contributor to the accident. The usage of eye protection at the time of accidents conforms closely to normal use of eye protection by mineworkers, indicating it is not a substantial contributor.

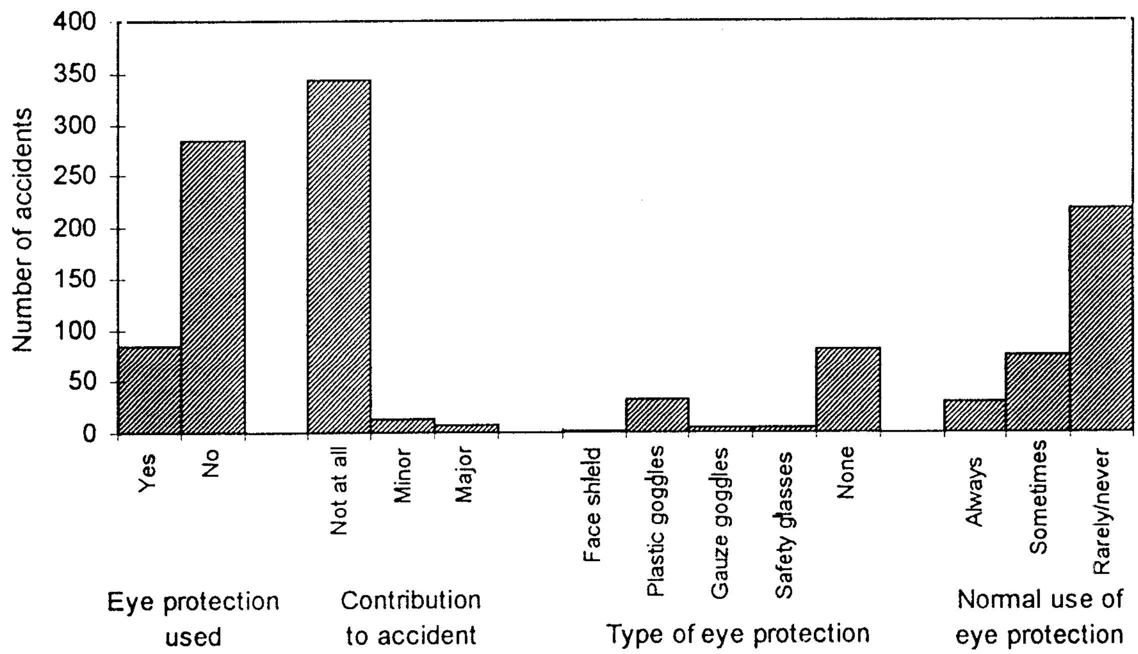

Figure 4.1.2h Distribution of accidents in relation to use of eye protection

Figure 4.1.2i provides the results of visual acuity and colour perception tests for mineworkers associated with the accidents included in the survey.

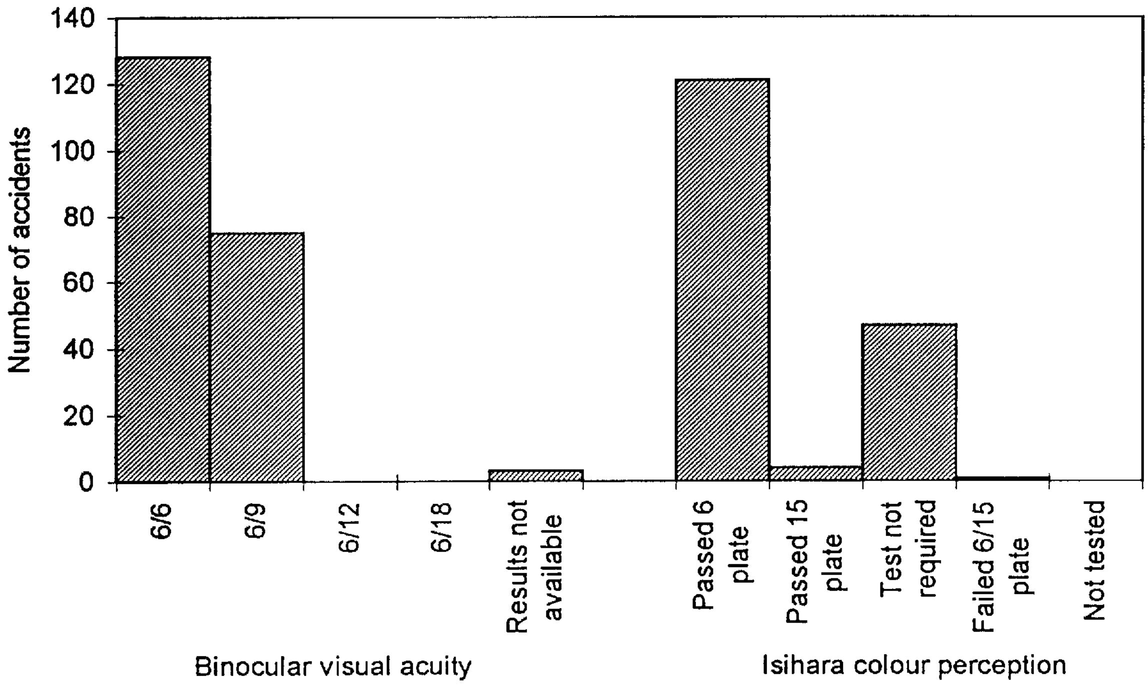

Figure 4.1.2i Distribution of accidents in relation to visual acuity of workers associated with occurrences

Unfortunately, the distributions cannot be normalized against the population of mineworkers on the mines participating to identify whether there is any difference in risk among the various eyesight categories. However, the distributions of visual acuity for mineworkers involved in accidents are not believed to be atypical of the overall population of mineworkers.

4.1.3 Noise

Figure 4.1.3a provides the distribution of normal noise levels in the work places where accidents occurred in comparison with the average for that type of work place. 91 per cent of the responses indicated an "Average" noise level, with the remainder distributed approximately equally to "Quieter than average" and "Louder than average".

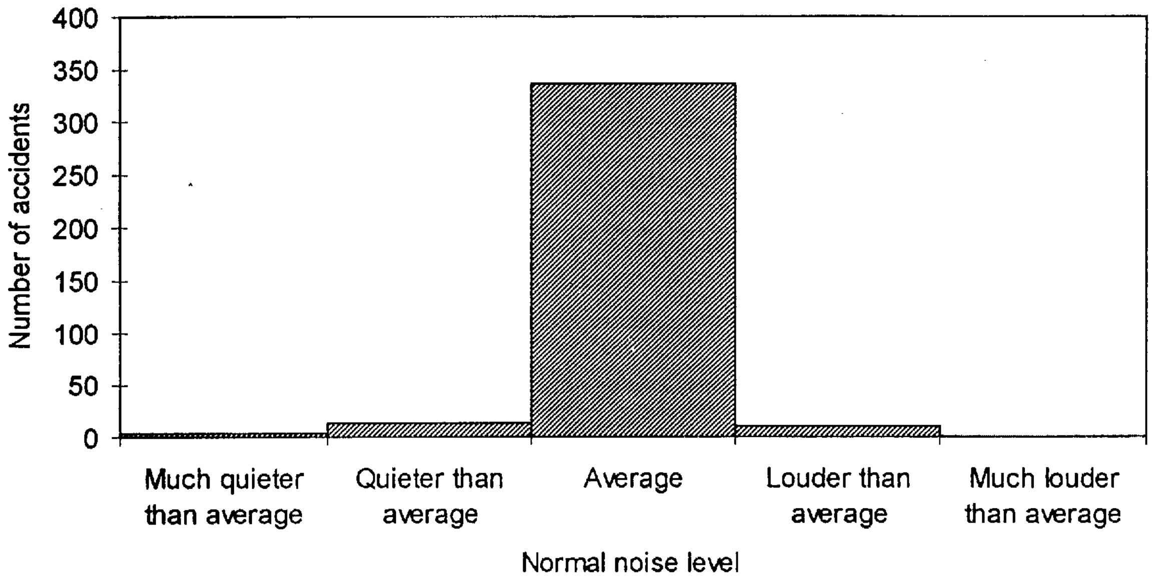

Figure 4.1.3a Distribution of accidents in relation to normal noise in the workplaces where accidents occurred

Table 4.1.3a confirms that there are no statistically significant departures from the average noise level, indicating that the frequency of accidents does not depend on the normal noise level of the work place.

Table 4.1.3a

Summary statistics for normal noise in workplace compared with average for that type of workplace on the mine

Mine/ commodity	Number	Average	Standard deviation	Standard error	t-statistic
G1	29	0,07	0,37	0,069	1,00
G2	20	-0,15	0,49	0,109	-1,37
G3	60	0	0,58	0,075	0,00
G4	29	0	0,00	0,000	-
G5	70	-0,09	0,50	0,060	-1,42
G6	74	0,01	0,12	0,014	1,00
Gold	282	-0,02	0,41	0,025	-0,87
P1	22	0	0,31	0,066	0,00
P2	65	-0,05	0,21	0,026	-1,76
Platinum	87	-0,03	0,24	0,026	-1,35
Total	369	-0,02	0,38	0,020	-1,24

Figure 4.1.3b provides the results of the closest available noise survey to the time of the accident, where a preponderance of responses indicating levels below 80 dB is noted. Although no data is available to perform a formal normalization of the accident rates with noise level, this distribution would appear to indicate that accidents tend to occur more frequently at noise levels substantially lower than those normally encountered in hardrock mining operations. This observation is interpreted to be indicative of an understatement of the actual noise levels that prevailed rather than a real effect.

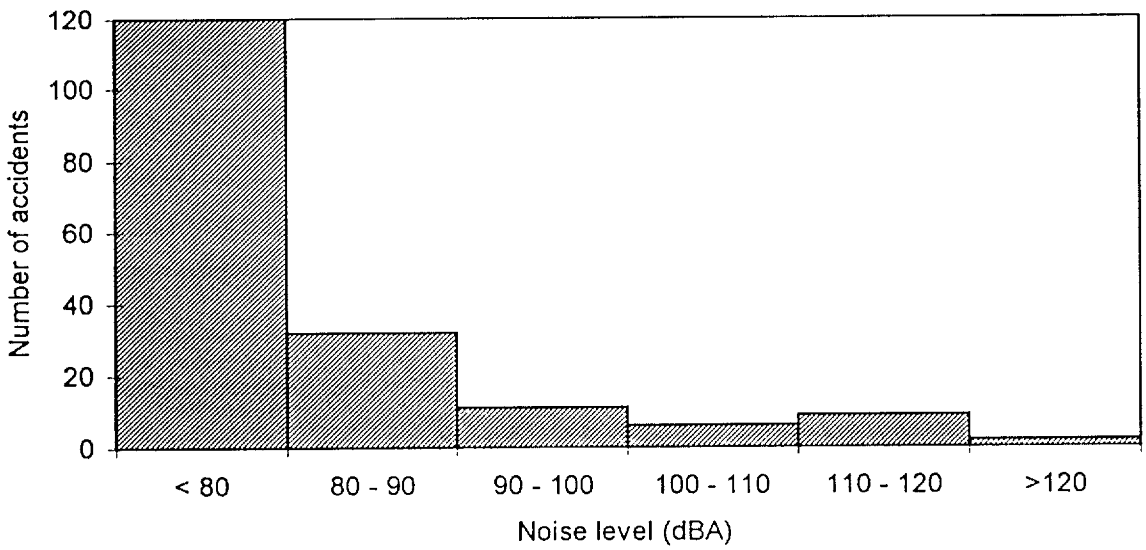

Figure 4.1.3b Distribution of accidents in relation to noise levels where accidents occurred

Figure 4.1.3c provides the distribution of noise levels at the time of the accident compared with the norm for the workplace. A symmetrical distribution is again observed, with 89 per cent of the responses in the "Normal" category. Table 4.1.3b shows that only in the case of the average for the platinum mines and on mine P2 in particular are there statistically significant departures from a normal noise level at the time of the accident. In these two cases, it is indicated that accidents tend to occur with greater frequency when noise levels are quieter than normal, which would seem to be questionable.

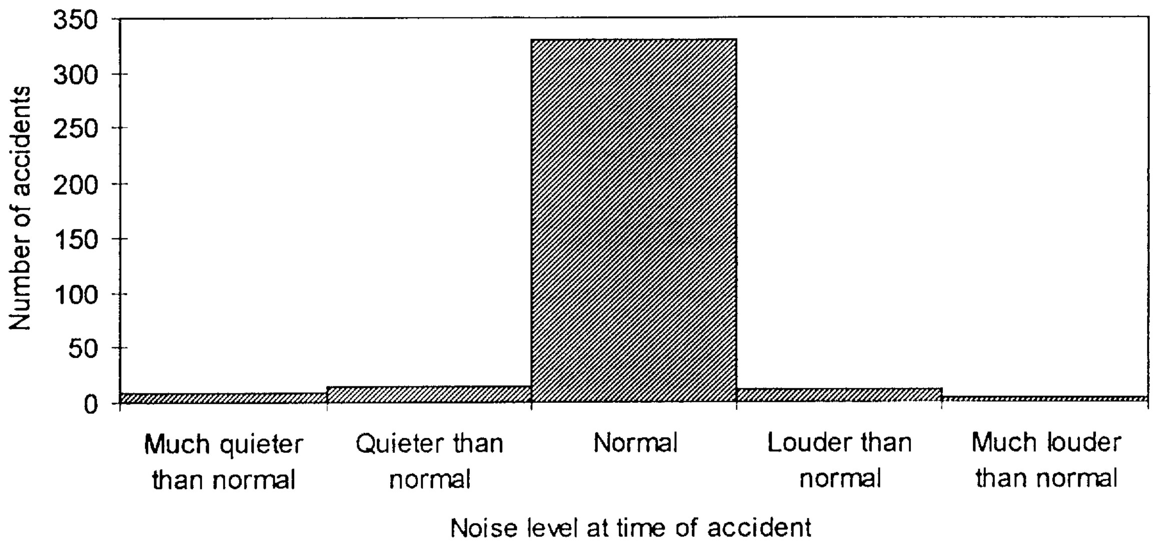

Figure 4.1.3c Distribution of accidents in relation to noise levels at time of occurrence compared with norm for workplace

Table 4.1.3b

Summary statistics for noise at time of accident compared with norm for that workplace

Mine/ commodity	Number	Average	Standard deviation	Standard error	t-statistic
G1	29	0,14	0,52	0,096	1,44
G2	20	-0,10	0,45	0,100	-1,00
G3	60	-0,07	0,63	0,082	-0,81
G4	29	0	0,00	0,000	-
G5	70	-0,03	0,59	0,070	-0,41
G6	74	0,01	0,12	0,014	1,00
Gold	282	-0,01	0,47	0,028	-0,38
P1	22	-0,23	0,53	0,113	-2,02
P2	65	-0,05	0,33	0,041	-1,14
Platinum	87	-0,09	0,39	0,042	-2,18
Total	369	-0,03	0,45	0,023	-1,27

Figure 4.1.3d shows that on a few occasions, 10 out of 369, a sudden increase in noise level was observed immediately prior to the accident taking place. In all these cases, however, it is unclear whether the increase contributed to the accident.

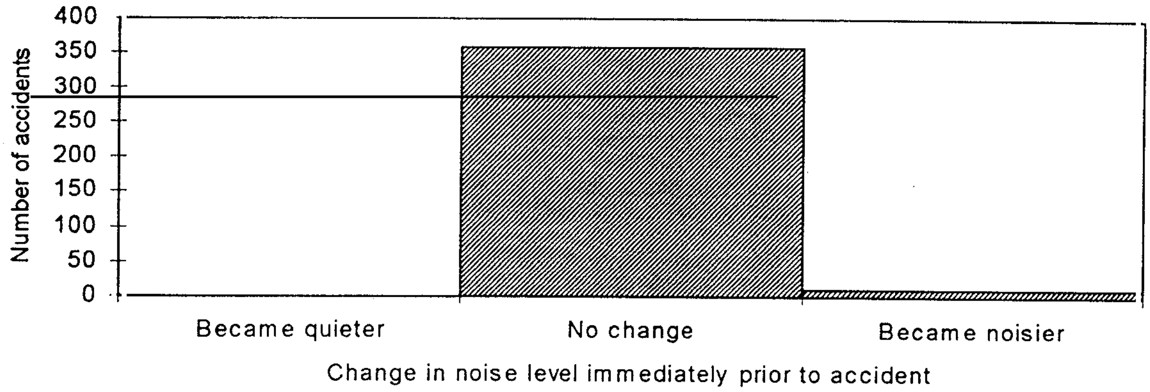

Figure 4.1.3d Distribution of accidents in relation to changes in noise level immediately prior to occurrence

Figure 4.1.3e provides data on the availability, usage and effectiveness of audible warning signals. It is evident that in relatively few instances (10 per cent) were audible alarms available but where they were were they tended to be activated and heard. This implies that, despite a warning signal being heard when activated, it was ineffective in preventing the accident. Without data on the frequency of audible warning signals preventing an accident, it is not possible to make an assessment of their degree of effectiveness.

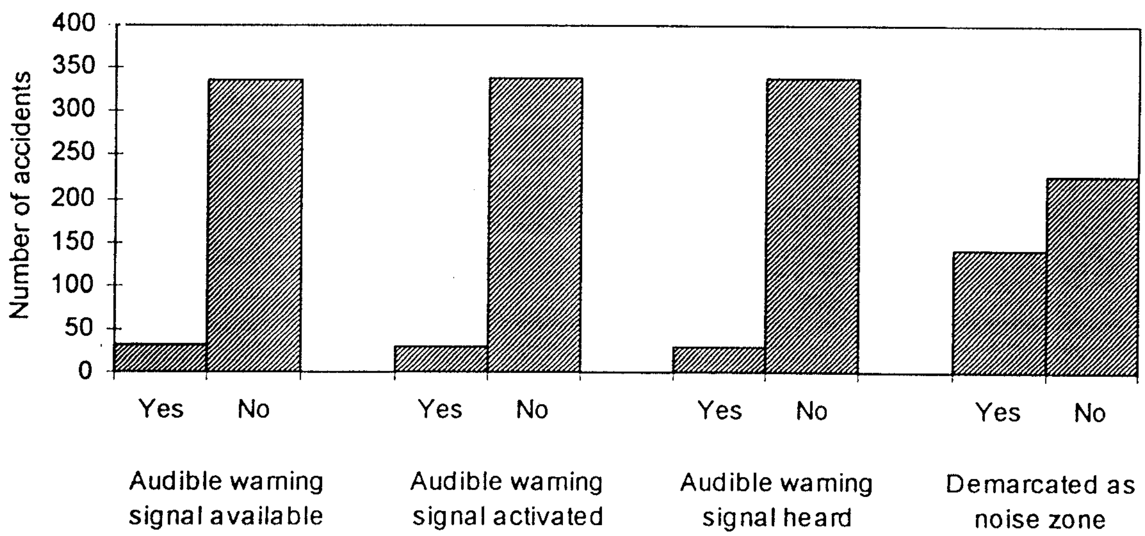

Figure 4.1.3e Distribution of accidents in relation to audible warning signals

Figure 4.1.3f provides information relating to the usage of hearing protection devices. As normally identified, the usage of hearing protection at the time of accidents amounted to only 25 per cent. This statistic tends to support the low assessed contribution of hearing protection device usage to the occurrence of accidents, as it is inferred subjectively from the above percentage that the risk of accidents is independent of the usage of hearing protection.

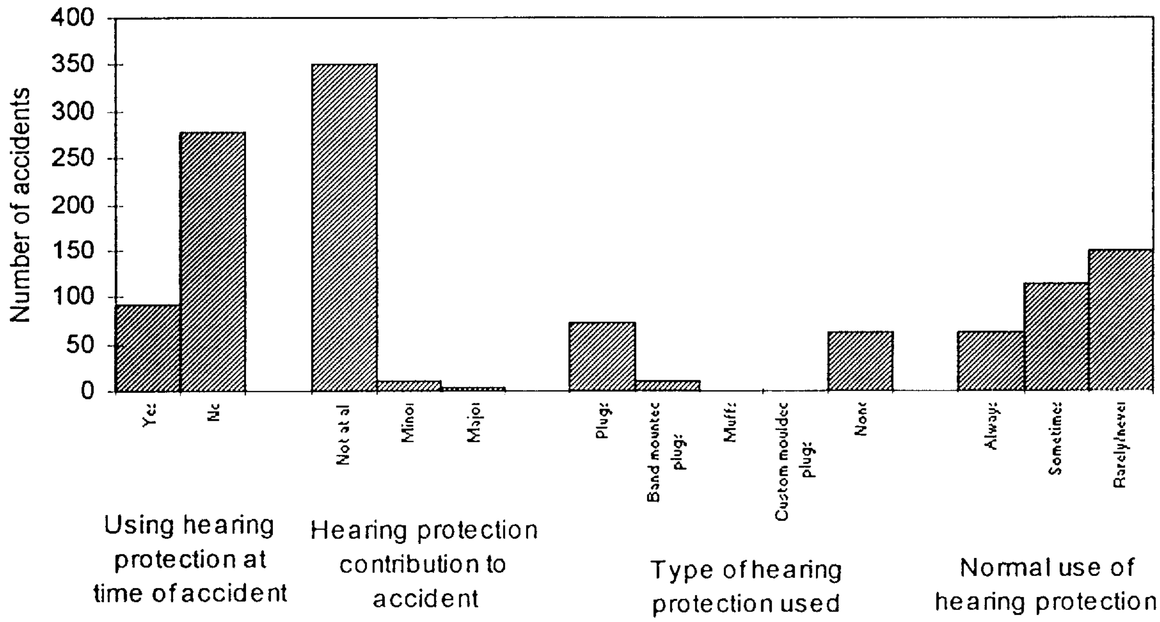

Figure 4.1.3f Distribution of accidents in relation to use of hearing protection devices

The distribution of hearing acuity levels of those mineworkers identified as responsible for the accidents studied is presented in Figure 4.1.3g. This distribution is believed to be representative of the overall mineworker population on the mines participating in the study, thereby indicating that hearing acuity does not influence the risk of accidents. However, again in this case, no rigorous data was available on the distribution of hearing acuity of the mineworker population in general to permit a reliable normalization, and hence assessment of the effect on safety risk.

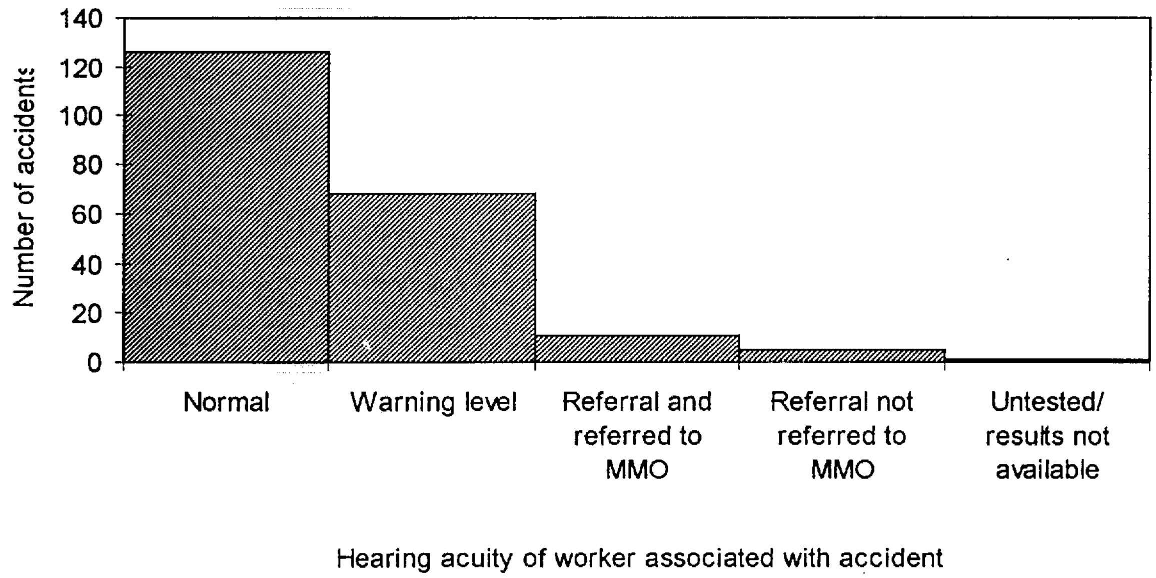

Figure 4.1.3g Distribution of accidents in relation to hearing acuities of workers associated with occurrences

4.1.4 Vibration and confined space

Levels of whole body/hand arm vibration at the time of accident, as compared with the norm for the mining operation during which the accident took place, are presented in Figure 4.1.4a.

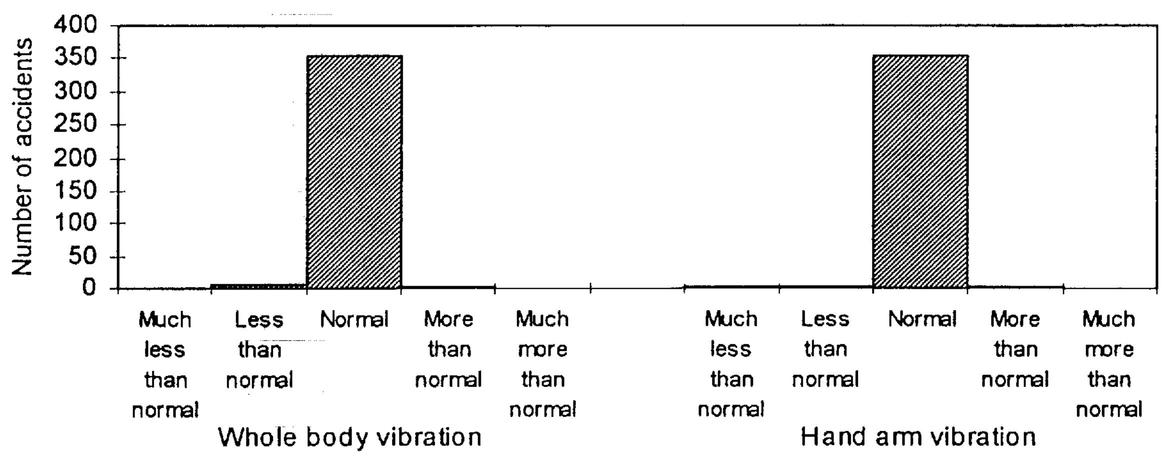

Figure 4.1.4a Distribution of accidents in relation to vibration at time of accident compared with norm for workplace

Both the distributions presented in this figure display a dominance of the "Normal" response, indicating that there is a limited or no influence of vibration on safety risk. The statistics presented in Tables 4.1.4a and 4.1.4b reinforce this finding since in no instance does the t statistic indicate a departure of the average response from "Normal"

Table 4.1.4a

Summary statistics for whole body vibration at time of accident compared with norm for that workplace

Mine/ commodity	Number	Average	Standard deviation	Standard error	t-statistic
G1	29	0	0,00	0,000	-
G2	20	-0,15	0,49	0,109	-1,37
G3	56	-0,04	0,19	0,025	-1,43
G4	28	0	0,00	0,000	-
G5	70	0,01	0,21	0,025	0,57
G6	74	0	0,00	0,000	-
Gold	277	-0,01	0,19	0,011	-1,27
P1	22	0	0,00	0	-
P2	65	0,02	0,22	0,027	0,57
Platinum	87	0,01	0,19	0,020	0,58
Total	364	-0,01	0,19	0,010	-0,83

Table 4.1.4b

Summary statistics for hand arm vibration at time of accident compared with norm for that workplace

Mine/ commodity	Number	Average	Standard deviation	Standard error	t-statistic
G1	29	0	0,00	0,000	-
G2	20	-0,10	0,45	0,100	-1,00
G3	56	-0,04	0,19	0,025	-1,43
G4	28	0	0,00	0,000	-
G5	70	0,01	0,36	0,043	0,33
G6	74	0	0,00	0,000	-
Gold	277	-0,01	0,23	0,014	-0,77
P1	22	0	0,00	0,000	-
P2	63	0,02	0,22	0,028	0,57
Platinum	85	0,01	0,19	0,020	0,58
Total	362	-0,01	0,22	0,012	-0,47

Figure 4.1.4b also confirms that a sudden change in vibration level immediately prior to an accident taking place was rarely experienced.

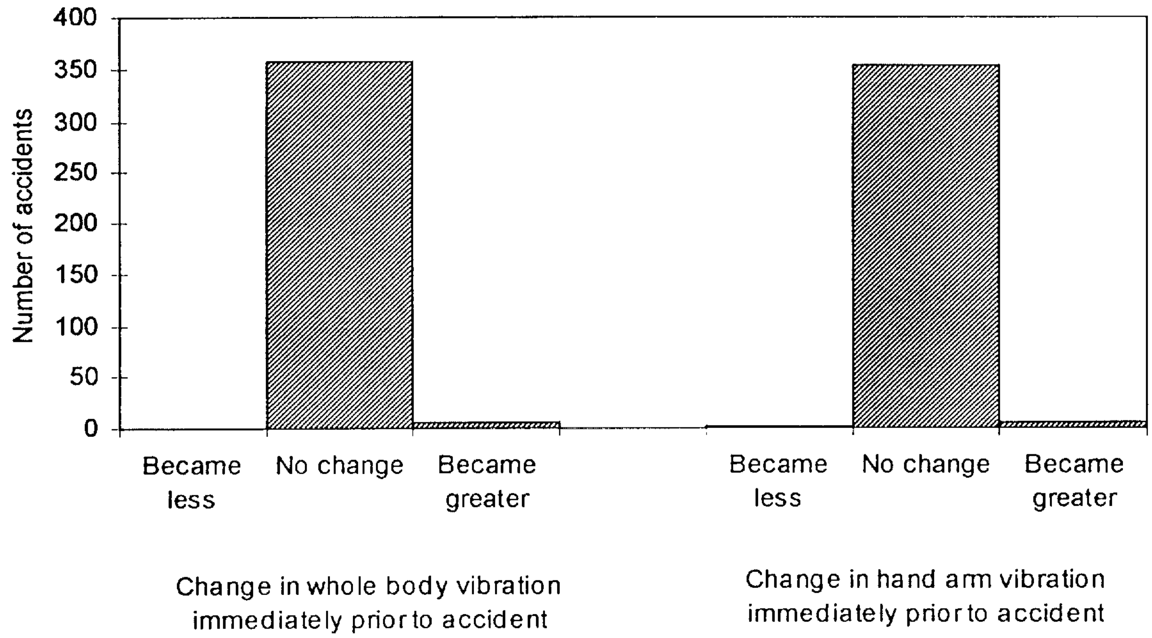

Figure 4.1.4b Distribution of accidents in relation to changes in vibration immediately prior to occurrence

Figure 4.1.4c shows that a lesser or greater space for movement than average is associated with accidents more frequently than is the case with most of the other variables considered, with only 86 per cent of responses falling into the category "Average". The departure from "Average" is, however, evenly balanced in either direction, indicating that the distribution of space for movement under which accidents take place is representative of the distribution under which mining is carried out.

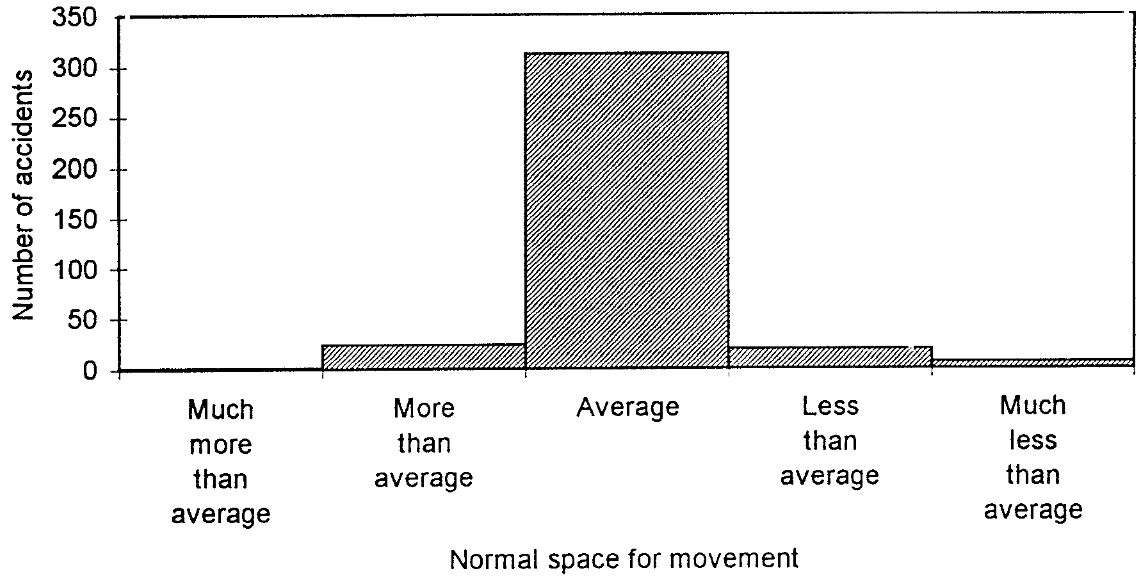

Figure 4.1.4c ***Distribution of accidents in relation to normal space for movement compared with average in workplaces where accidents occurred***

Table 4.1.4c confirms the associations reflected in Figure 4.1.4c, where only on mine G3 is it observed to be statistically significant that accidents take place more frequently when there is a greater than average space for movement.

Table 4.1.4c

Summary statistics for normal space for movement in workplace compared with average for that type of workplace on the mine

Mine/ commodity	Number	Average	Standard deviation	Standard error	t-statistic
G1	29	0,21	0,56	0,104	1,99
G2	20	-0,10	0,45	0,100	-1,00
G3	56	-0,16	0,60	0,080	-2,02
G4	29	0	0,00	0,000	-
G5	70	0,13	0,61	0,073	1,76
G6	74	-0,01	0,12	0,014	-1,00
Gold	278	0,01	0,48	0,029	0,38
P1	22	0,05	0,38	0,080	0,57
P2	64	0,06	0,39	0,049	1,27
Platinum	86	0,06	0,39	0,042	1,39
Total	364	0,02	0,46	0,024	0,92

Figure 4.1.4d provides the distribution of space for movement separately for the vertical and both horizontal dimensions. The category less than 1 metre contributes over half of each of the three distributions indicating that, in the majority of accidents, at least in one dimension, the space for movement is restricted to less than 1 metre. While again the lack of useable normalizing data prevents reliable assessment of the influence of space for movement on safety risk, it is considered that the distributions presented in Figure 4.1.4d are representative of typical mining operations.

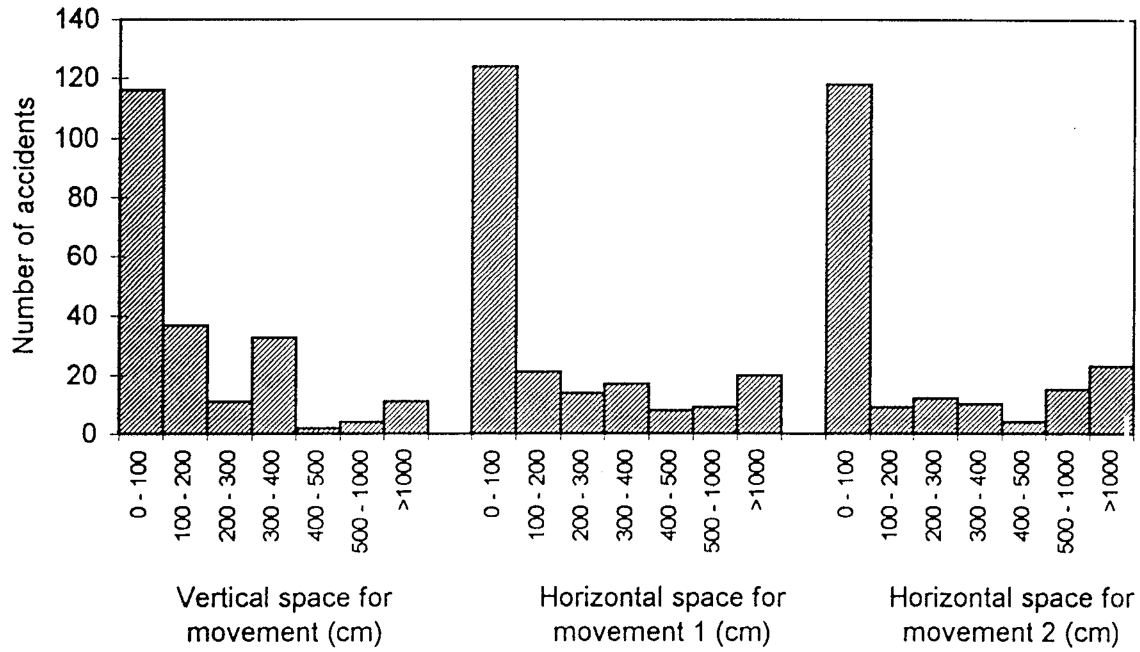

Figure 4.1.4d Distribution of accidents in relation to space for movement in workplaces where accidents occurred

Figure 4.1.4e and Table 4.1.4d show that there is a substantially greater departure of responses from "Normal" on the issue of space for movement at the time of the accident compared to the norm for the employee involved. While two of the mines, G2 and G6, indicate that a greater number of their accidents occur under conditions when space for movement is greater than the norm, two of the mines, G5 and P2, indicate the reverse. The combination of these responses lead to the finding that, for the gold mines, accidents tend to take place more frequently when space for movement is greater than the norm and, for the platinum mines, the reverse holds. The same finding as for gold mines applies to the overall data. On mine G6, the responses indicate that almost all accidents happen when space for movement is greater than normal for the employee involved in the accident.

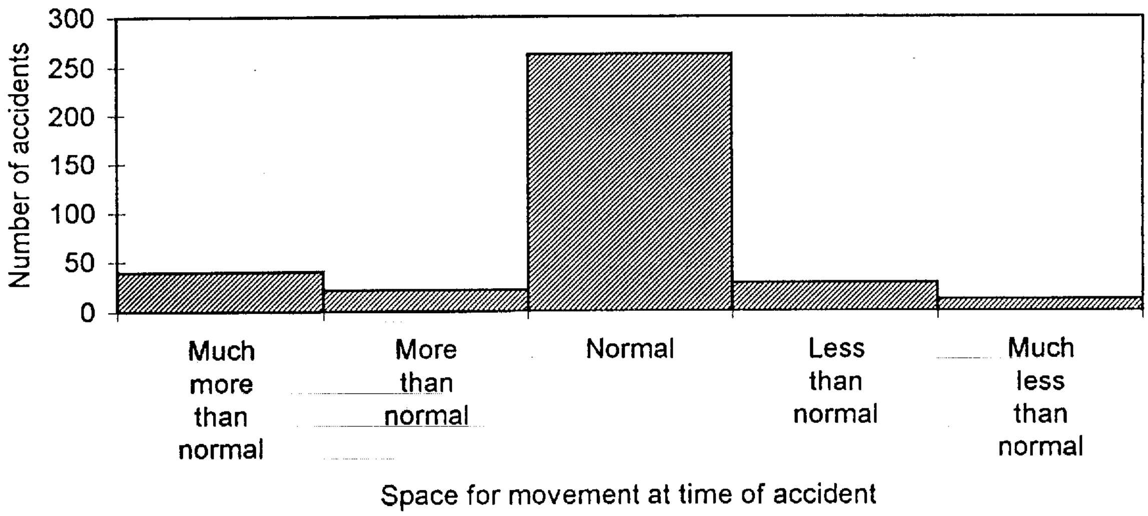

Figure 4.1.4e Distribution of accidents in relation to space for movement at time of occurrence compared with norm for workplace

Table 4.1.4d

Summary statistics for space for movement at time of accident compared with norm for that employee

Mine/ commodity	Number	Average	Standard deviation	Standard error	t-statistic
G1	29	0,17	0,60	0,112	1,54
G2	20	-0,35	0,67	0,150	-2,33
G3	56	-0,09	0,55	0,073	-1,22
G4	29	0,07	0,26	0,048	1,44
G5	70	0,24	0,71	0,085	2,86
G6	74	-0,97	1,02	0,119	-8,21
Gold	278	-0,22	0,88	0,053	-4,10
P1	22	0,18	0,66	0,142	1,28
P2	62	0,15	0,51	0,064	2,25
Platinum	84	0,15	0,55	0,060	2,59
Total	362	-0,13	0,83	0,043	-2,99

4.1.5 Workers' physical condition

Figure 4.1.5a illustrates the distribution of the ages of mineworkers linked with accidents. The distribution reveals a paucity of mineworkers with an age less than 30, indicating that mineworkers from this age group are less likely to be responsible for accidents than in the older age groups. This is based on an assumed distribution of mineworker ages in which there are similar proportions of mineworkers in each of the categories <30, 30-40 and 40-50, with a reduced proportion in the category >50.

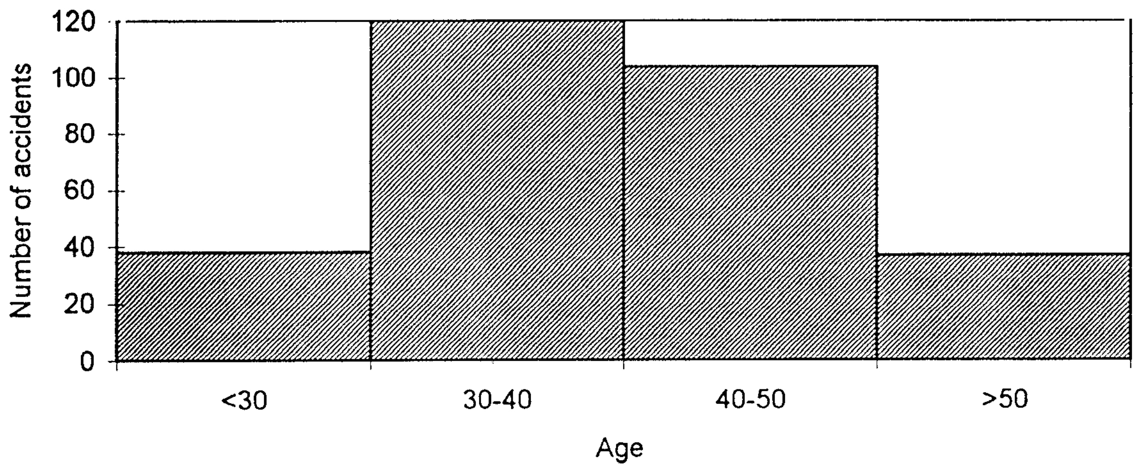

Figure 4.1.5a Distribution of accidents in relation to age of workers associated with occurrences

The results of analysing the experience of mineworkers associated with accidents are presented in Figure 4.1.5b. The distribution of mining experience presented in the left half of the figure is considered to accord reasonably with the distribution of experience in the overall mineworker population, thereby indicating that mining experience has little influence on the rate of occurrence of accidents. In the right hand half of the figure, the distribution of experience at the accident location reflects a short average of only 9,2 months, with the majority of mineworkers linked to accidents having less than 6 months working experience at the accident site. It is considered likely that these statistics may be representative of the overall mineworker experience at any particular work place, although the distribution may provide an indication that mineworkers with less than 6 months experience at a work place may be more likely to be involved in an accident. Reliable normalization data would be required to permit a more rigorous evaluation of this issue.

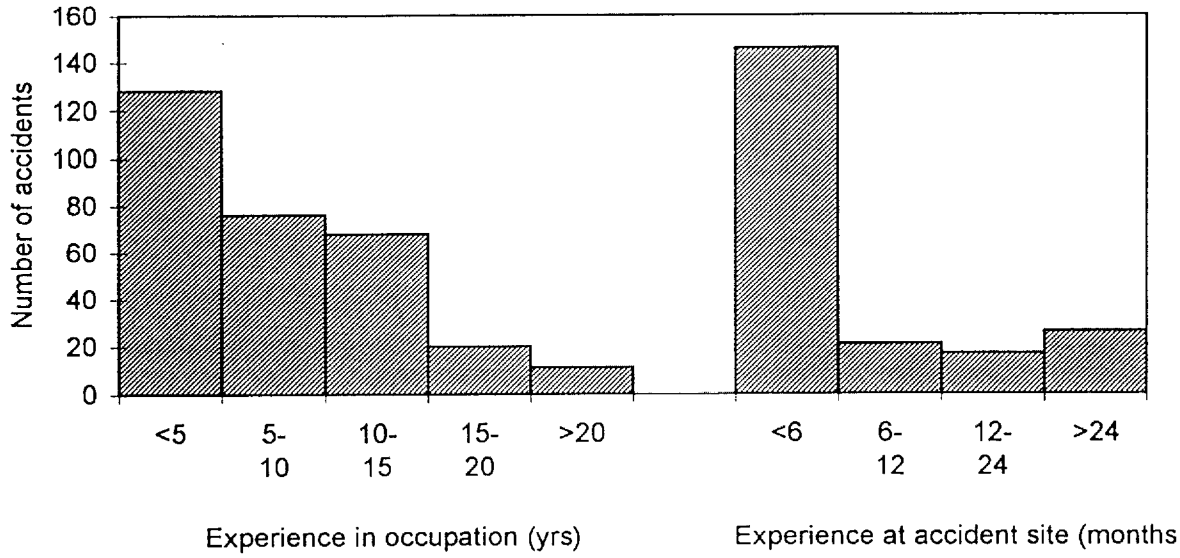

Figure 4.1.5b Distribution of accidents in relation to mining experience of workers associated with occurrences

Figure 4.1.5c provides the distributions of time spent on duty or at the work place prior to the accident taking place. A pronounced peak in the distribution is observed between 2 and 6 hours into the working shift and between 2 and 4 hours at the work place. These peaks are construed as being indicative of the nature of work being carried out at various stages of the shift, with the first and last 2 hours of the shift being relatively safer with travelling and waiting being the major activities. However, fatigue may also be a contributory factor. It should be noted that these distributions mirror the time at which reportable accidents take place as reported in *Ashworth and Phillips (1997:74-78).*

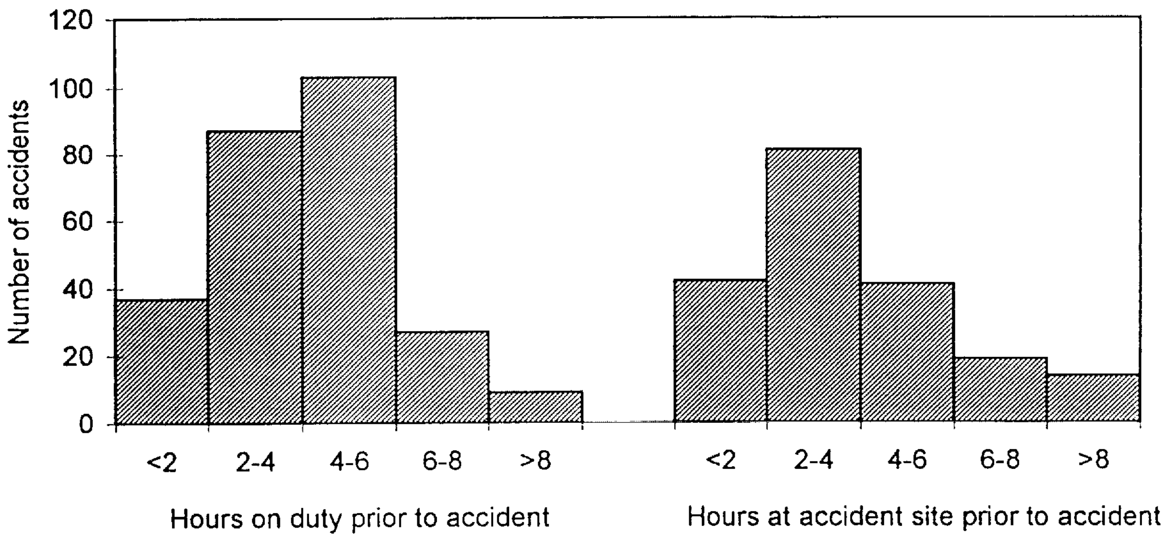

Figure 4.1.5c Distribution of accidents in relation to time on duty of workers associated with occurrences

Figure 4.1.5d indicates that, almost exclusively, no deviation from a normal shift or change in shift had been experienced by the mineworker identified as responsible for the accident in the previous 48 hours.

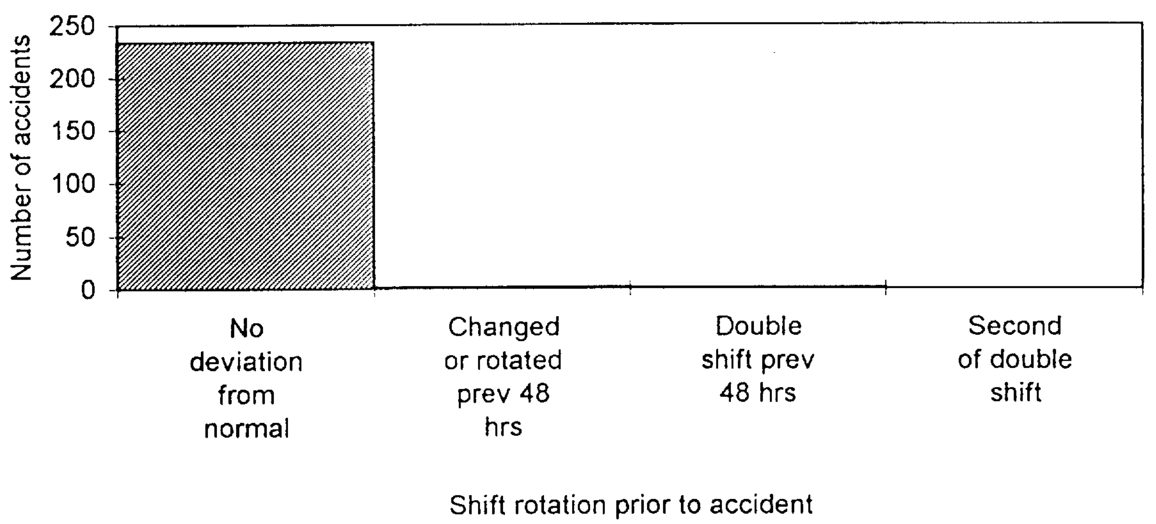

Figure 4.1.5d Distribution of accidents in relation to shift rotation of workers associated with occurrences

Similarly, Figure 4.1.5e reveals that only in about 1 per cent of cases did a mineworker identified as responsible for the accident suffer from any form of adverse medical condition.

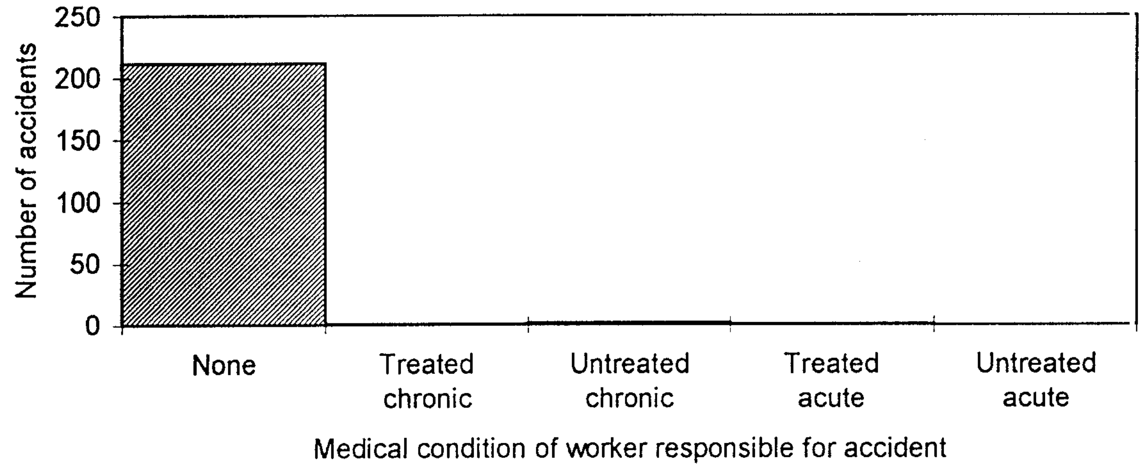

Figure 4.1.5e Distribution of accidents in relation to medical conditions of workers associated with occurrences

4.1.6 Review of qualitative data and summary of key findings

Analysis of the qualitative information concerning the roles through which mineworkers contributed to accidents reveal many immediate causes which may be attributable to adverse environmental conditions. For example, a failure to comply with a procedure, which is frequently cited as a factor in the accident's occurrence, may be attributable to fatigue resulting from adverse environmental conditions. However, this immediate cause could also result from a range of other root cause factors such as inadequate training, poor management or supervision or inappropriateness of the procedure, and there is limited evidence in the supplementary data acquisition forms to provide insight in this regard.

A role which was cited in approximately 10 of the 369 returns was a lack of concentration. While not exclusively attributable to environmental conditions, it appears reasonable to assume that this immediate cause would be exacerbated by adverse environmental conditions and accordingly, there is some positive evidence of a role for environmental factors as subordinate root cause contributors to the occurrence of accidents.

In summary, the following main points are concluded from the analysis of supplementary data from accident investigations:

- There is no evidence that environmental factors have a strong influence on accident rate.

- It appears that heat and confined space, and to a lesser extent visibility, attract greater attention, or are perceived as more relevant than noise and vibration as the former factors showed more departures from an "Average" or "Normal" response.

- In the cases of heat stress and visibility, the statistics indicate that there is a small increase in accident occurrence when conditions are better than average, but this is believed to be indicative of "defensive posturing" in completing the supplementary data acquisition forms.

- In general and with some notable exceptions, accident investigations appear to be confined to the determination of an immediate cause without sufficient probing to identify underlying root causes or contributors. While the supplementary data acquisition form, for this reason and also to facilitate its completion, focused on the collection of factual observations regarding environmental conditions, it is suggested that a lack of a culture of root cause analysis led to the "Average" or "Normal" response being selected more frequently than should have been the case. In this regard, the form requested that deviations from the norm or sudden changes be supplemented with information to explain the shift and this may have further deterred some investigators from indicating conditions other than "Average" or "Normal".

- The lack of reliable normalization data detracts from the potential for developing associations between accident rates and the extent of exposure to environmental conditions. However, in the context of the previous two "bullet points" and given the information normally included in ventilation returns, the value of normalization data would have been restricted to the development of associations involving heat related environmental parameters and the physiological parameters associated with mineworkers' sensory acuity and heat tolerance.

4.2 Safety risk assessments

The findings of the five risk assessment processes were consolidated and examined for any association of environmental factors with safety hazards. The focus was on two categories of risk, high and medium. Category was determined on the basis of risk ranking, where a possible casual factor which could lead to an accident was rated in accordance with its estimated probability or frequency of occurrence (on a scale of 1 to 5) and the maximum reasonable consequence should it occur (also scaled from 1 to 5). The combination of the two ratings determined the risk ranking, which was used to classify the hazard on the basis of the categories below and the matrix presented in Table 4.2a.

Risk Ranking	Risk Level
1 - 6	High
7 - 19	Medium
20 - 25	Low

Table 4.2a

Basis for ranking and categorising risk

		Probability				
		1	2	3	4	5
Consequence	1	1	2	4	7	11
	2	3	5	8	12	16
	3	6	9	13	17	20
	4	10	14	18	21	23
	5	15	19	22	24	25

In order to provide a perspective of environmental issues' relative importance in comparison with other potential causes or contributors to accidents, their incidence and prevalence among all issues identified was determined. These findings are summarized in Table 4.2b.

Table 4.2b

Collective identification and prevalence of environmental factors among all issues associated with high risk safety hazards

Type of Mine	Operation or Process Examined	Total Issues Identified (n)	Environmental Issues Identified (n)	Prevalence of Environmental Issues (%)
Platinum	Examination & support Drilling	46 16	4 5	87313
Both Platinum	Both operations examined	62	9	145
Gold	Drilling and cleaning Re-entry examination Horizontal transport	48 23 59	1 4 9	21174153
All Gold	All operations examined	130	14	108
Gold and Platinum combined	All processes and operations examined	192	23	120

It should be noted that in some instances risk assessments for different processes or hazards identified common environmental and/or non-environmental issues, resulting in some duplication, but both categories were similarly affected and the influence on overall results was negligible.

The risk assessments' association of environmental factors with high risk safety hazards was analysed, in order to enable the ranking of environmental factors in terms of their potential to cause or contribute to underground accidents. The findings are presented in Table 4.2c.

Table 4.2c

Analysis and prevalence of environmental factors associated with high risk safety hazards

Type of Mine	Operation or Process Examined	High risk safety hazards associated with environmental factors (n)				
		Heat Stress	Visibility	Noise	Explosive Gas	Total
Platinum	Examination & support	2			2	4
	Drilling		2	2	1	5
Both Platinum	Both operations examined	2	2	2	3	9
Gold	Drilling and cleaning		1			1
	Re-entry examination	1		1	2	4
	Horizontal transport		5	4		9
All Gold	All operations examined	1	6	5	2	14
Gold and Platinum combined	All processes and operations examined during safety risk assessments	3	8	7	5	23
		Prevalence relative to all environmental factors				
		13,0%	34,8%	30,4%	21,7%	99,9%

Environmental factors associated with high risk safety hazards, in order of prevalence and, thus importance (as assessed by participants) were:

- Visibility inhibitors (34,8%)
- Noise (30,4%)
- Explosive gas (21,7%)
- Heat stress (13,0%)

Once the associations of environmental factors with high risk safety hazards had been examined, linkages with medium risk safety hazards were considered. Medium risk hazards were defined as those assigned a risk ranking ranging from 7 to 19. The findings, combined with those relating to high risk hazards (previously presented in Table 4.2c) are summarized in Table 4.2d.

Table 4.2d

Analysis and prevalence of environmental factors associated with high and medium risk safety hazards

Type of Mine	Operation or Process Examined	Medium and high risk safety hazards associated with environmental factors (n)						
		Heat Stress	Visibility	Noise	Restricted Space	Vibration	Explosive Gas	Total
Platinum	Examination & support	2					2	4
	Drilling	1	3	2	1	1	1	9
Both Platinum	Both operations examined	3	3	2	1	1	3	13
Gold	Drilling and cleaning	1	5	2		1	1	10
	Re-entry examination	2		1			2	5
	Horizontal transport	6	7				2	15
All Gold	All operations examined	9	12	3		1	5	30
Gold and Platinum combined	All processes and operations examined during safety risk assessments	12	15	5	1	2	8	43
		Prevalence relative to all hazards associated with environmental factors						
		27,9%	34,9%	11,6%	2,3%	4,7%	18,6%	100,0%

Inspection of Table 4.2d reveals that the environmental issues associated with medium risk safety hazards, as ranked by participants, were:

- Vibration (4,7%)
- Restricted space (2,3%)

These two environmentally-related issues, while regarded as noteworthy, were not perceived to give rise to high risk safety hazards, hence their medium risk classification.

When environmental factors associated with both medium and high risk safety hazards were combined, their importance relative to all factors associated with these hazards was found to be 22,4 per cent. The rankings of environmental factors among themselves by prevalence were as follows:

- Visibility inhibitors (34,9%)
- Heat stress (27,9%)
- Explosive gas (18,6%)
- Noise (11,6%)
- Vibration (4,7%)
- Restricted space (2,3%)

4.3 Employees' perceptions

The paired comparison data obtained from mine employees during the perception survey were statistically analysed to identify trends and to test the validity of the data. A total of 707 respondents provided data via the questionnaire proformas presented in Appendix 2, yielding a total of 16 614 paired comparisons between environmental and non-environmental factors. Of these, 5 651 or 34,0 per cent identified the environmental factor as more important than the non-environmental factor, i.e. non-environmental issues were seen as more important by a ratio of nearly 2:1. One of the issues in the environmental category, viz. ergonomics, was partitioned into two sub-issues, these being restricted space and vibration.

4.3.1 Overall analysis of the data

The statistics for employees' selection of an environmental factor over a non-environmental factor as a potential cause or contributor to underground accidents are presented by category in Table 4.3.1a. The first section of the table indicates the number of occasions on which each comparison was responded to. Here, the number of responses to the comparison between heat and equipment & materials is indicated as 1 031. Ideally all paired comparisons should have been responded to the same number of times but some minor deviations occurred. These were the result of the four variants of the questionnaire not being distributed in exactly equal numbers and a small number of completed questionnaires with one or more responses omitted. The second section of the table indicates the number of responses selecting the environmental factor as a more important cause or contributor. Thus, in comparing the importance of heat with that of equipment & materials, 353 responses selected heat. In the third section of the table, each cell contains the percentage of occasions on which a particular comparison selected the environmental factor as the more likely cause. Thus, in 34,2 per cent of the comparisons between heat and equipment & materials, a greater importance was attributed to heat.

Table 4.3.1a

Summary of paired comparison results by environmental factor and category of non-environmental factors

Non-environmental category	Environmental factor			
	Heat	Visibility	Noise	Ergonomics
	No. of responses to the indicated comparison			
Equipment & Materials	1 031	1 050	1 046	1 032
Standards & Procedures	1 027	1 034	1 054	1 042
Training & Competence	1 043	1 034	1 028	1 040
Management & Supervision	1 047	1 040	1 034	1 032
	No. of responses selecting the environmental factor			
Equipment & Materials	353	403	340	306
Standards & Procedures	363	401	380	337
Training & Competence	330	366	356	304
Management & Supervision	336	399	365	312
	% of responses selecting the environmental factor			
Equipment & Materials	34,2%	38,4%	32,5%	29,7%
Standards & Procedures	35,3%	38,8%	36,1%	32,3%
Training & Competence	31,6%	35,4%	34,6%	29,2%
Management & Supervision	32,1%	38,4%	35,3%	30,2%

An inspection of values in Table 4.3.1a for the selection of individual environmental factors over non-environmental factors indicates selection rates for environmental factors ranging from 29,2 to 38,8 per cent, i.e. no substantial deviations from the overall average of 34,0 per cent. Although inspection indicates limited distinctions between the various environmental and non-environmental factors, an appropriate statistical test to establish the significance of the observed variation is the chi-squared (X^2) test. This enables an evaluation of the hypothesis that all percentages are, in fact, realizations drawn from an underlying constant percentage. Based on the computed X^2 statistic, it may be determined whether there is evidence indicating that different cells should be assigned different percentages.

In performing the X^2 test, the expected number of responses selecting an environmental factor is calculated for each cell according to the hypothesis being tested, in this case, the hypothesis of a constant percentage selecting environmental factors for every cell. If true, this would yield the distribution of responses presented in Table 4.3.1b.

Table 4.3.1b

Expected selection of the environmental factor under the hypothesis of a common level of perceived importance for all environmental factors over all non-environmental factors

Non-environmental category	Number of responses expected to select the given environmental factor			
	Heat	Visibility	Noise	Ergonomics
Equipment & Materials	350,7	357,1	355,8	351,0
Standards & Procedures	349,3	351,7	358,5	354,4
Training & Competence	354,8	351,7	349,7	353,7
Management & Supervision	356,1	353,7	351,7	351,0

The X^2 statistic is computed by firstly calculating the value of $(O_i-E_i)^2/E_i$ for each cell, where O_i represents the actual number of responses selecting an environmental factor in that cell and E_i refers to the expected value according to the hypothesis being tested. The sum of $(O_i-E_i)^2/E_i$ over all the cells of the table is then a realization from a X^2 distribution, with the number of degrees of freedom being the number of cells less the number of parameters calculated from the observations and used to determine the expected values. In this case, the X^2 statistic is 43,2 with 15 degrees of freedom. The probability of observing a X^2 statistic as great as this is less than 1 per cent, so it may be concluded that the likelihood of the observed responses being drawn from a population with the same perceived importance for each environmental factor over each non-environmental factor is remote. In other words, the responses indicate different perceptions of the relative importance of environmental factors for each comparison between environmental and non-environmental issues.

The X^2 test was repeated to consider the hypothesis that each non-environmental factor is perceived as having the same relative importance, but with each environmental factor perceived to have a different relative importance. Accordingly, the expected number of responses selecting the environmental factor was calculated for each cell of the table, as the number of paired comparisons relevant to that cell multiplied by the overall percentage of occasions where the relevant environmental factor was selected. Table 4.3.1c indicates the selection percentage for each environmental factor.

Table 4.3.1c

Percentage of responses selecting each environmental factor

Environmental factor	Percentage of paired comparisons selecting the environmental factor
Heat	33,3%
Visibility	37,7%
Noise	34,6%
Ergonomics	30,4%

The hypothesis that each non-environmental factor is perceived as having the same relative importance with each environmental factor perceived to have a different relative importance yielded a X^2 statistic of 9,0 with 12 degrees of freedom. The probability of obtaining this value or greater exceeds 10 per cent, indicating that much of the variability observed between responses is accounted for by respondents' different perceptions regarding the importance of the environmental factors. As a corollary to this observation, it would follow that there was comparatively less distinction made among the various non-environmental factors considered in the questionnaire.

More formal testing of this latter point was undertaken by computing the X^2 statistic for the hypothesis that each non-environmental factor has a different relative importance while each environmental factor has the same relative importance. The percentage of paired comparisons selecting the environmental factor for each of the categories of non-environmental factors is indicated in Table 4.3.1d.

Table 4.3.1d

Percentage of responses selecting the environmental factor for each non-environmental category

Non-environmental category	Percentage of paired comparisons selecting the environmental factor
Equipment & Materials	33,7%
Standards & Procedures	35,6%
Training & Competence	32,7%
Management & Supervision	34,0%

The X^2 statistic for the hypothesis that each non-environmental factor has a different relative importance and each environmental factor has the same relative importance was 37,9 with 12 degrees of freedom. The probability of obtaining this value or greater is less than 1 per cent. It is also noteworthy that the X^2 statistic is only slightly reduced from that produced for the hypothesis that the responses can be modelled by a common overall percentage. It is therefore concluded that the non-environmental factors were considered to be of similar importance to each other by the respondents.

From the above, it is concluded that the observed variation in responses is appropriately modelled by the variation in perceived importance of environmental factors, as reflected in Table 4.3.1c. Visibility was regarded as the most important environmental factor, while ergonomics, representing vibration and restricted space, was seen as the least important issue in the environmental category.

A statistical analysis was performed to evaluate the consistency with which the various statements representing individual non-environmental factors were rated. Table 4.3.1e lists the statements (abridged from the original questionnaires) representing the various non-environmental factors, under the four non-environmental categories considered.

Table 4.3.1e

Non-environmental factor statements by category

Non-environmental factor category	State-ment Code	Summary of statement in questionnaire
Equipment & Materials	E&M 1	Machinery giving trouble
	E&M 2	Equipment not properly maintained
	E&M 3	Safety guards missing or non-functional
	E&M 4	Correct equipment or materials not available
	E&M 5	Correct safety or protective equipment unavailable/unused
	E&M 6	Hazardous chemicals or dangerous materials used
Standards & Procedures	S&P 1	Standards are impractical or too time-consuming
	S&P 2	Standards require too much work to apply
	S&P 3	Workers don't understand procedures or standards
	S&P 4	Equipment used incorrectly or unsafely
	S&P 5	Work done without using safe work practices
	S&P 6	Standards and safety procedures ignored
Training & Competence	T&C 1	Workers have not had proper training or refreshers
	T&C 2	Workers are new to job or have not had much experience
	T&C 3	Workers do not know the hazards and how to avoid them
	T&C 4	Workers do not know the task they are busy with
	T&C 5	Workers have been drinking alcohol or smoking dagga
	T&C 6	Workers are sick, unfit or tired
Supervision & Management	M&S 1	Supervisors do not check work and instruct/advise workers
	M&S 2	Supervisors do not check that work is done to standard
	M&S 3	Supervisors have not told workers how to do job
	M&S 4	Not enough workers to do the job
	M&S 5	Supervisors use inexperienced or untrained workers
	M&S 6	Workers do not understand supervisor's instructions

Table 4.3.1f provides the observed percentage of paired comparison responses in which the environmental factor was rated as more important than the non-environmental factor. Under the hypothesis that these observed percentages were generated from a common percentage of 34,0 per cent, a X^2 statistic of 368,0 with 95 degrees of freedom was calculated. The probability of obtaining such a value is less than 1 per cent, so it may be concluded that a common percentage is not an appropriate data model.

The hypothesis that each environmental factor has a common characteristic importance (as tabulated in Table 4.3.1c) yielded a X^2 statistic of 335,7 with 92 degrees of freedom. Unlike the case where only categories of non-environmental factors were considered, the probability of achieving a X^2 statistic of this magnitude or greater is less than 1 per cent. This indicates a considerable divergence of opinion among respondents regarding the importance of individual issues within the non-environmental categories.

Table 4.3.1f

Summary of results of comparisons between environmental factors and non-environmental factors

Non-environmental factor statement code	Percentage of paired comparisons selecting the indicated environmental factor				
	Heat	Visibility	Noise	Vibration	Confined space
E&M 1	34,8%	50,9%	41,1%	36,5%	
E&M 2	40,9%	34,2%	35,8%	30,7%	
E&M 3	28,0%	28,3%	25,3%	24,2%	
E&M 4	31,4%	33,9%	24,4%		22,2%
E&M 5	28,3%	36,7%	28,8%		25,6%
E&M 6	42,4%	46,1%	39,3%		38,9%
S&P 1	41,3%	44,4%	44,0%		45,3%
S&P 2	44,7%	50,3%	54,2%	38,2%	
S&P 3	30,2%	32,3%	36,0%		34,4%
S&P 4	34,0%	33,1%	31,5%	28,2%	
S&P 5	30,5%	34,3%	27,7%		30,7%
S&P 6	31,1%	38,3%	21,9%	18,5%	
T&C 1	23,3%	27,2%	20,8%	16,0%	
T&C 2	27,2%	27,3%	33,0%		38,5%
T&C 3	37,9%	34,1%	40,2%	29,2%	
T&C 4	39,3%	41,0%	40,2%	19,8%	
T&C 5	18,9%	28,7%	23,8%		24,6%
T&C 6	44,1%	53,6%	47,5%		48,6%
M&S 1	32,7%	38,7%	39,7%	24,9%	
M&S 2	23,9%	29,8%	31,6%		30,0%
M&S 3	27,0%	41,0%	24,4%	28,7%	
M&S 4	50,9%	54,2%	49,4%	43,3%	
M&S 5	26,3%	33,1%	34,1%		26,1%
M&S 6	32,2%	32,5%	32,8%		28,1%

The hypothesis that each non-environmental factor category has a common characteristic perceived importance (as tabulated in Table 4.3.1d) yielded a X^2 statistic of 364,4 with 92 degrees of freedom. The probability of achieving this value is less than 1 per cent. Furthermore, it is noted that the reduction in the X^2 statistic is less than for the hypothesis of a common percentage for each of the environmental factors. This observation is in line with the analysis by category reported earlier, where the hypothesis of a common percentage for each environmental factor also led to a greater reduction in the X^2 statistic.

The hypothesis that each non-environmental factor statement has its own characteristic perceived importance yielded a X^2 statistic of 105,6 with 72 degrees of freedom. Although this is a substantial reduction in the X^2 statistic, the probability of obtaining this value or greater is still less than 1 per cent. This result indicates that certain of the statements representing non-environmental factors included in the questionnaire were relatively unpopular while for others the converse was true.

Table 4.3.1g provides information in this regard, with a high percentage indicating a higher selection rate for the environmental factor and, hence, a lower selection rate for the non-environmental factor being considered. In each of the four non-environmental categories, the constituent statements are sorted in order of decreasing popularity, i.e. increasing selection of the environmental factors they were evaluated against.

From the current statistical analysis it is also concluded that the variation in selection of various environmental issues is significant, as was found previously in considering the results in Table 4.3.1c.

Table 4.3.1g

Percentage of responses identifying the environmental factor for each non-environmental statement

Category	Non-environmental statement		Selection of Env. Factor
	Code	Summary from questionnaire	
Equipment & Materials	E&M 3	Safety guards missing or non-functional	26,6%
	E&M 4	Correct equipment or materials unavailable	27,8%
	E&M 5	Safety/protective equipment unavailable/unused	29,9%
	E&M 2	Equipment not properly maintained	35,4%
	E&M 1	Machinery giving trouble	40,9%
	E&M 6	Hazardous chemicals or dangerous materials used	41,7%
Standards & Procedures	S&P 6	Standards or safety procedures ignored	27,5%
	S&P 5	Work done without safe work practices	30,9%
	S&P 4	Equipment used incorrectly or unsafely	31,6%
	S&P 3	Workers don't understand standards/procedures	33,2%
	S&P 1	Standards impractical or too time-consuming	43,7%
	S&P 2	Standards require too much work to apply	46,8%
Training & Competence	T&C 1	Workers have not had proper training or refreshers	21,8%
	T&C 5	Workers drinking alcohol or smoking dagga	24,0%
	T&C 2	Workers new to job or inexperienced	31,5%
	T&C 4	Workers do not know task they are busy with	34,9%
	T&C 3	Workers do not know hazards/how to avoid them	35,5%
	T&C 6	Workers are sick, unfit or tired	48,6%
Management & Supervision	M&S 2	Supervisors not ensuring work done to standard	28,8%
	M&S 5	Supervisors use inexperienced/untrained workers	29,9%
	M&S 3	Supervisors haven't told workers how to do job	30,4%
	M&S 6	Workers don't understand supervisor's instructions	31,4%
	M&S 1	Supervisors don't check work and instruct workers	34,0%
	M&S 4	Not enough workers to do the job	49,4%

Examination of the hypothesis that the responses are modelled by the average selection percentage for each environmental factor combined with the average selection percentage for each non-environmental factor statement yielded a X^2 statistic of 72,9 with 69 degrees of freedom. The probability of obtaining such a X^2 statistic exceeds 10 per cent. This indicates that there are no second-order effects present in the data, and that the responses may be adequately modelled in terms of the overall selection of environmental and non-environmental factors. In other words, when a non-environmental factor is commonly selected as the more important influence, it is consistently preferred over all the environmental factors and not selectively preferred in comparison to one of the environmental factors. It is therefore concluded that the percentages provided in Tables 4.3.1c and 4.3.1g constitute a suitable overall model for responses to the paired comparisons.

4.3.2 Analysis of responses by type of mine

Respondents were employed at one of two platinum mines or at one of six gold mines. No attempt was made to ascertain which specific mine employed the respondents and, accordingly, they were categorised either as gold or platinum mine employees. However, this should not be construed as implying that the results reported are necessarily indicative of any generalized difference in perceptions (or lack thereof) between gold and platinum mine employees.

Table 4.3.2a indicates the number of respondents from each type of mine and the overall percentage of responses selecting the environmental factor for each type.

Table 4.3.2a

Number of respondents and selection of environmental factors by mine type

Type of Mine	Respondents (n)	Percentage of responses selecting the environmental factor
Gold	308	33,2%
Platinum	398	34,7%

The hypothesis that the percentages observed for selection of environmental factors were drawn from a distribution with a common average of 34,0 per cent yielded a X^2 statistic of 2,7 with 1 degree of freedom. The probability of achieving such a statistic exceeds 10 per cent, indicating that there is no evidence of a difference between workers from the two types of mines in their opinions regarding the importance of environmental factors.

Table 4.3.2b provides the identification percentages for each pair of environmental and non-environmental factors by type of mine. The hypothesis that these percentages could have been drawn from a distribution having a specific level of perceived importance for each environmental factor (as tabulated in Table 4.3.1c), but a common level of perceived importance for each non-environmental factor and no difference between the two types of mines yielded a X^2 statistic of 29,8 with 28 degrees of freedom. The probability of obtaining such a X^2 statistic exceeds 10 per cent and, accordingly, it may be concluded that there is no statistical evidence for different levels of perceived importance for specific environmental or non-environmental factors relative to type of mine.

It is therefore concluded that the perceptions of employees on the two types of mine regarding the importance of environmental factors in accident causation are essentially the same.

Table 4.3.2b

Percentage of responses selecting the environmental factor for each combination of mine type, environmental factor and non-environmental factor

Type of Mine	Non-environmental category	Percentage of responses selecting the indicated environmental factor			
		Heat	Visibility	Noise	Ergonomics
Gold	Equipment & Materials	36,1%	34,3%	36,9%	29,0%
	Standards & Procedures	32,7%	35,6%	37,0%	32,8%
	Training & Competence	28,6%	31,3%	34,1%	29,3%
	Management & Supervision	31,8%	36,1%	34,3%	31,0%
Platinum	Equipment & Materials	32,7%	41,7%	29,1%	30,2%
	Standards & Procedures	37,4%	41,2%	35,3%	32,0%
	Training & Competence	34,1%	38,6%	35,1%	29,2%
	Management & Supervision	32,3%	40,2%	36,1%	29,7%

4.3.3 Analysis of responses by workplace type

An examination of the data was made to determine whether employees from different workplace types exhibited different levels of perceived importance for environmental factors. The distribution of workers by workplace type is provided in Table 4.3.3a. Similar workplace types were consolidated, in order to provide a sufficiently large sample for each grouping.

Table 4.3.3a

Distribution of respondents by workplace type

Workplace type	Respondents (n)	Workplace grouping
Stope	306	**Stope**
Development end	106	**Development**
Haulage or crosscut	97	**Horizontal transport**
Tips or station	40	
Underground workshop	75	**Other**
Surface (workers with u/g exp)	2	
Other	73	

The chi-squared test was again applied, in this instance, to determine the degree of difference in responses among various workplace groupings. The hypothesis that workers from each grouping assign the same degree of importance to environmental factors was examined. Table 4.3.3b indicates the overall percentage of paired comparison responses selecting the environmental factor by workplace grouping.

Table 4.3.3b

Percentage of responses selecting the environmental factor for each workplace grouping

Workplace grouping	Percentage of responses selecting the environmental factor
Stope	36,2%
Development end	36,2%
Horizontal transport	33,5%
Other	28,5%

The X^2 statistic determined for the hypothesis that these tabulated percentages are drawn from a population with common mean of 34,0 per cent for all working place types is 46,4 with 3 degrees of freedom. The probability of obtaining this value or greater is less than 0,1 per cent, providing strong evidence that workers from different working place types regard the importance of environmental factors differently. Not surprisingly, workers from stopes and development ends attached greater importance to environmental factors than did workers from the horizontal transport system or from other working place types, such as workshops or surface locations.

Table 4.3.3c indicates the selection of each environmental factor over each non-environmental factor by workplace type. The hypothesis that the percentage of selection for environmental factors could be adequately explained by a model of common perceived importance for each environmental factor, irrespective of workplace type and the non-environmental factor being compared with (as previously indicated in Table 4.3.1c), was assessed by means of the X^2 test. This test yielded a X^2 statistic of 91,1 with 60 degrees of freedom. The probability of obtaining this value or greater is less than 1 per cent, so it may be concluded that the model is not adequate and that the observed differences in responses between workplace types are significant.

Table 4.3.3c

Percentage of responses selecting the environmental factor for each combination of workplace type, environmental factor and non-environmental factor

Workplace	Non-environmental category	Percentage of responses selecting the indicated environmental factor			
		Heat	Visibility	Noise	Ergonomics
Stope	Equipment &	40,6%	41,6%	34,6%	32,3%
	Standards & Procedures	40,7%	43,2%	37,3%	32,2%
	Training & Competence	33,3%	37,0%	34,1%	28,9%
	Management & Supervision	34,2%	43,5%	36,4%	29,5%

Workplace	Non-environmental category	Percentage of responses selecting the indicated environmental factor			
		Heat	Visibility	Noise	Ergonomics
Development	Equipment & Materials	29,9%	39,6%	35,0%	28,9%
	Standards & Procedures	39,2%	36,9%	38,7%	38,3%
	Training & Competence	40,1%	40,1%	37,1%	33,8%
	Management & Supervision	30,4%	40,6%	40,4%	31,3%
Horizontal transport	Equipment & Materials	30,7%	39,9%	34,4%	27,7%
	Standards & Procedures	31,6%	41,9%	37,1%	33,7%
	Training & Competence	26,1%	35,6%	39,1%	32,5%
	Management & Supervision	28,9%	30,9%	31,5%	34,0%
Other	Equipment & Materials	27,1%	29,2%	24,0%	26,3%
	Standards & Procedures	25,7%	28,6%	30,6%	27,1%
	Training & Competence	28,5%	29,3%	29,8%	24,0%
	Management & Supervision	31,7%	32,6%	33,6%	27,7%

Of particular significance is the above-average selection of heat over equipment & materials and standards & procedures as a cause of accidents among employees in stopes, and the below-average selection of noise over equipment & materials as causes of accidents among employees in other working places.

Testing the model that each environmental factor/workplace type combination has a common percentage for identification of the environmental factor, irrespective of which non-environmental factor is considered, yields a X^2 statistic of 33,6 with 48 degrees of freedom. The probability of obtaining this value or greater exceeds 10 per cent, so it may be concluded that this model is a good representation of the data. The model is summarized in Table 4.3.3d.

Table 4.3.3d

Average selection of the environmental factor by workplace type and environmental factor

Workplace	Average percentage of responses selecting the indicated environmental factor			
	Heat	Visibility	Noise	Ergonomics
Stope	37,2%	41,4%	35,6%	30,7%
Development end	34,9%	39,3%	37,8%	33,0%
Horizontal transport	29,3%	37,1%	35,5%	32,0%
Other	28,2%	29,9%	29,5%	26,3%

4.3.4 Analysis of responses by department

A statistical analysis was performed in order to identify any differences in the perceived importance of environmental factors among employees in different job categories or departments. The distribution of respondents participating in the survey is presented in Table 4.3.4a by department, with the categories combined as indicated to avoid excessively small groupings.

Table 4.3.4a

Distribution of respondents by department and job category grouping

Department	Respondents (n)	Job category grouping
Mining	459	**Mining**
Engineering	111	**Engineering**
Transport	70	**Transport**
Ventilation	27	**Other**
Safety	12	
Other	21	

The average percentages for selection of the environmental factor by department are presented in Table 4.3.4b. (It will be noted that these percentages mirror those presented in Table 4.3.3b, where workplace type was considered.) The X^2 statistic for the hypothesis that these percentages are drawn from a common value of 34,0 per cent is 38,2 with 3 degrees of freedom. The probability of obtaining a X^2 statistic of this magnitude is less than 0,1 per cent, indicating that perceived importance of environmental factors depends on job category or department. It will be noted that individuals in mining occupations appear to attach greater importance to environmental factors than do employees in other departments.

Table 4.3.4b

Average selection of the environmental factor by department

Department	Average percentage for selection of the environmental factor
Mining	35,8%
Engineering	31,8%
Transport	29,9%
Other	27,8%

Table 4.3.4c reflects the percentage identification of the environmental factor for each combination of department grouping, environmental factor and non-environmental factor.

Table 4.3.4c

Percentage of responses selecting the environmental factor by department, environmental factor and non-environmental factor

Department	Non-environmental category	Percentage of responses selecting the indicated environmental factor			
		Heat	Visibility	Noise	Ergonomics
Mining	Equipment & Materials	38,3%	41,0%	33,8%	31,3%
	Standards & Procedures	38,9%	41,4%	37,4%	33,4%
	Training & Competence	33,3%	36,2%	35,5%	30,0%
	Management & Supervision	34,0%	40,6%	37,2%	31,1%

Department	Non-environmental category	Percentage of responses selecting the indicated environmental factor			
		Heat	Visibility	Noise	Ergonomics
Engineering	Equipment & Materials	25,7%	31,8%	29,1%	28,4%
	Standards & Procedures	32,1%	33,1%	30,4%	31,0%
	Training & Competence	27,1%	37,2%	35,0%	32,0%
	Management & Supervision	31,6%	36,8%	35,1%	32,3%
Transport	Equipment & Materials	21,6%	34,0%	32,0%	25,2%
	Standards & Procedures	20,7%	37,6%	39,3%	33,7%
	Training & Competence	26,4%	30,4%	33,3%	27,5%
	Management & Supervision	21,9%	35,9%	30,4%	28,2%
Other	Equipment & Materials	33,7%	34,6%	25,0%	21,7%
	Standards & Procedures	28,2%	31,5%	31,5%	24,7%
	Training & Competence	33,0%	33,0%	29,4%	20,7%
	Management & Supervision	26,7%	22,9%	27,3%	20,4%

The hypothesis that the observed responses resulted from a specific perceived importance for each environmental factor (as previously presented in Table 4.3.1c) with a common perceived importance for each non-environmental factor across all departments gave a X^2 statistic of 74,8 with 60 degrees of freedom. The probability of obtaining such a X^2 statistic is between 5 and 10 per cent, suggesting that the hypothesis of a common perceived importance for each environmental factor across all departments is invalid, although this finding is not conclusive.

The hypothesis that employees in each department have a characteristic perception that environmental factors are more likely causes of accidents than non-environmental factors produced a X^2 statistic of 73,0 with 60 degrees of freedom. The probability of obtaining this statistic is greater than 10 per cent, indicating that the observed variability in responses is adequately explained by inter-departmental differences in the perceived importance of environmental factors with regard to accident occurrences.

If a specific preference for each environmental factor/ department combination is assigned as reflected in Table 4.3.4d, the X^2 test yields a statistic of 24,3 with 48 degrees of freedom. The probability of obtaining this value or greater exceeds 10 per cent, indicating that this model provides an excellent fit to the data.

Table 4.3.4d

Average selection of the environmental factor by department and environmental factor

Department	Average percentage for selection of the indicated environmental factor			
	Heat	Visibility	Noise	Ergonomics
Mining	36,1%	39,8%	35,9%	31,5%
Engineering	29,1%	34,7%	32,4%	30,9%
Transport	22,7%	34,5%	33,9%	28,6%
Other	30,5%	30,6%	28,3%	21,8%

4.3.5 Analysis of responses by job level

Another aspect considered in the analysis of results was the distinction between workers and supervisors/managers. Table 4.3.5a provides an analysis of the respondents' job levels and their perceptions regaarding the importance of environmental factors.

Table 4.3.5a

Distribution of respondents and their selection of environmental factors by job level

Job level	Respondents (n)	Percentage selection of the environmental factor
Worker	615	35,6%
Supervisor or Manager	85	22,0%

Testing the hypothesis that the percentages obtained in Table 4.3.5a are drawn from a distribution having a common preference of 34,0 per cent for environmental factors yielded a X^2 statistic of 95,7 with 1 degree of freedom. The probability of obtaining this value or greater is less than 0,1 per cent, indicating a substantial difference of opinion between workers and supervisors/managers regarding the importance of environmental factors.

Table 4.3.5b provides insights into the nature of the difference identified above.

Table 4.3.5b

Percentage of responses selecting the environmental factor for each combination of job level, environmental factor and non-environmental factor

Job level	Category	Percentage of responses selecting the indicated environmental factor			
		Heat	Visibility	Noise	Ergonomics
Worker	Equipment &	35,8%	39,2%	33,6%	31,4%
	Standards &	37,3%	42,0%	37,4%	34,3%
	Training &	32,6%	36,7%	36,8%	30,7%
	Management &	33,0%	39,6%	36,4%	32,4%
Supervisor or Manager	Equipment &	22,1%	31,1%	21,9%	15,4%
	Standards &	21,4%	17,1%	25,4%	17,5%
	Training &	24,2%	26,9%	19,4%	19,2%
	Management & Supervision	23,3%	26,7%	27,3%	13,8%

Inspection of the tabulated values reveals that there is a general difference between workers and supervisors/managers in the perceived importance of the environmental factor as compared with the non-environmental factor, with no specific paired comparison in which the two groupings exhibit either a greater or lesser difference of opinion.

Testing the hypothesis that information presented in Table 4.3.5b could reasonably have been drawn from the selections of environmental factors presented in Table 4.3.5a for both workers and supervisors/managers, irrespective of the environmental or non-environmental factor being considered, yielded a X^2 statistic of 58,3 with 30 degrees of freedom. The probability of obtaining this value or greater is between 0,1 and 0,5 per cent, indicating that this data model does not provide an adequate explanation for the variability observed.

Testing the model that each job level/non-environmental factor combination has its own characteristic preference percentage resulted in a X^2 statistic of 50,4 with 24 degrees of freedom. The probability of obtaining this value or greater is between 0,1 and 0,5 per cent. It is therefore concluded that the variations in selection percentages associated with job level and non-environmental factor do not adequately explain the observed variations in responses.

Table 4.3.5c

Average selection of the environmental factor by job level and environmental factor

Job level	Average percentage of responses selecting the indicated environmental factor			
	Heat	Visibility	Noise	Ergonomics
Worker	34,7%	39,4%	36,1%	32,2%
Supervisor or Manager	22,8%	25,3%	23,4%	16,4%

Testing the model that each job level/environmental factor combination has its own characteristic selection percentage for the environmental factor results in a X^2 statistic of 20,1 with 24 degrees of freedom. The probability of obtaining this value or greater exceeds 10 per cent, indicating that this data model, which is summarized in Table 4.3.5c, provides a good fit to the data. It is noteworthy that, despite the different levels of importance attached to environmental factors by supervisors/managers and workers, the two groups' rankings for environmental factors display a high degree of commonality.

4.3.6 Analysis of responses by experience

The questionnaires requested that respondents indicate their mining experience in two ways: the length of time for which they had been working in the mining industry and the year in which they started in their current occupation. Table 4.3.6a provides the distribution of respondents' experience measured on these two bases.

Table 4.3.6a

Relationship between mining experience and first year of current job

First year in current job	Number of respondents with given level of mining experience				
	≤5 years	6-10 years	11-15 years	16-20 years	>20 years
<1977					63
1977-1981				44	28
1982-1986			91	19	16
1987-1991		103	42	33	14
≥1992	88	76	60	14	11

Inspection of Table 4.3.6a indicates a strong correlation between the two variables considered, with many mineworkers having acquired most of their mining experience in their current occupation. It was therefore deemed appropriate to analyse the data only with respect to overall mining experience, irrespective of the year in which the respondent commenced his current job, as both sets of data are essentially similar.

The analysis was conducted by partitioning respondents into three experience bands, these being less than or equal to 10 years, 11 to 20 years and more than 20 years. Table 4.3.6b indicates the distribution of respondents across these bands and the percentages for their selection of the environmental factor as a more important cause of accidents.

Table 4.3.6b

Distribution of respondents by mining experience with percentage of responses selecting the environmental factor

Experience band	Number of respondents	Percentage of responses selecting the environmental factor
≤10 years	267	32,9%
11-20 years	303	34,5%
>20 years	132	35,0%

The hypothesis that these tabulated percentages are based on a common perceived importance for environmental factors irrespective of experience produced a X^2 statistic of 3,7 with 2 degrees of freedom. The probability of obtaining the percentages reflected in Table 4.3.6b under this hypothesis exceeds 10 per cent, indicating that level of experience does not necessarily influence the perceived importance of environmental factors in accident occurrences.

Table 4.3.6c provides the percentage selection of the environmental factor for each environmental/non-environmental pairing by experience band.

Table 4.3.6c

Percentage of responses selecting the environmental factor by experience band, environmental factor and non-environmental factor

Experience band	Non-environmental Category	Percentage of responses selecting the indicated environmental factor			
		Heat	Visibility	Noise	Ergonomics
≤10 years	Equipment & Materials	34,9%	37,5%	30,8%	28,5%
	Standards & Procedures	34,5%	37,1%	36,0%	32,9%
	Training & Competence	31,3%	35,8%	31,2%	29,9%
	Management & Supervision	29,9%	35,2%	31,9%	28,8%

Experience band	Non-environmental Category	Percentage of responses selecting the indicated environmental factor			
		Heat	Visibility	Noise	Ergonomics
11-20 years	Equipment & Materials	32,3%	37,7%	32,6%	32,6%
	Standards & Procedures	36,5%	39,4%	36,4%	31,6%
	Training & Competence	31,8%	38,1%	35,6%	31,3%
	Management & Supervision	30,7%	37,7%	39,5%	28,8%
>20 years	Equipment & Materials	37,4%	41,1%	35,8%	25,5%
	Standards & Procedures	34,2%	40,3%	35,2%	33,2%
	Training & Competence	34,0%	43,6%	42,4%	29,4%
	Management & Supervision	37,3%	31,7%	29,4%	30,0%

Testing the hypothesis that the tabulated percentages are derived from the specific percentage selection of each environmental factor (as recorded in Table 4.3.3c) yielded a X^2 statistic of 31,4 with 44 degrees of freedom. The probability of obtaining such a value or greater exceeds 10 per cent, indicating that this data model is adequate to explain the observed variability without considering the effect of mining experience.

4.3.7 Validation of employee response data

Various tests were applied to test the validity of the responses as a basis for assessing the credibility of the findings. Considering the design of the questionnaires, the distribution of the number of responses selected from the left side of the page should be binomial, with a probability of 50 per cent that the response at the left is chosen. The actual distribution of left-side response selections is portrayed in Figure 4.3.7a. As reflected in the figure, the distribution has a bell-shaped appearance characteristic of the binomial distribution. The average number of responses per questionnaire chosen from the left was 11,9 subject to a standard error of 0,113, indicating that the response at the left was selected at a frequency within the range of what would normally be expected, i.e. an average of 12 left-side responses per questionnaire.

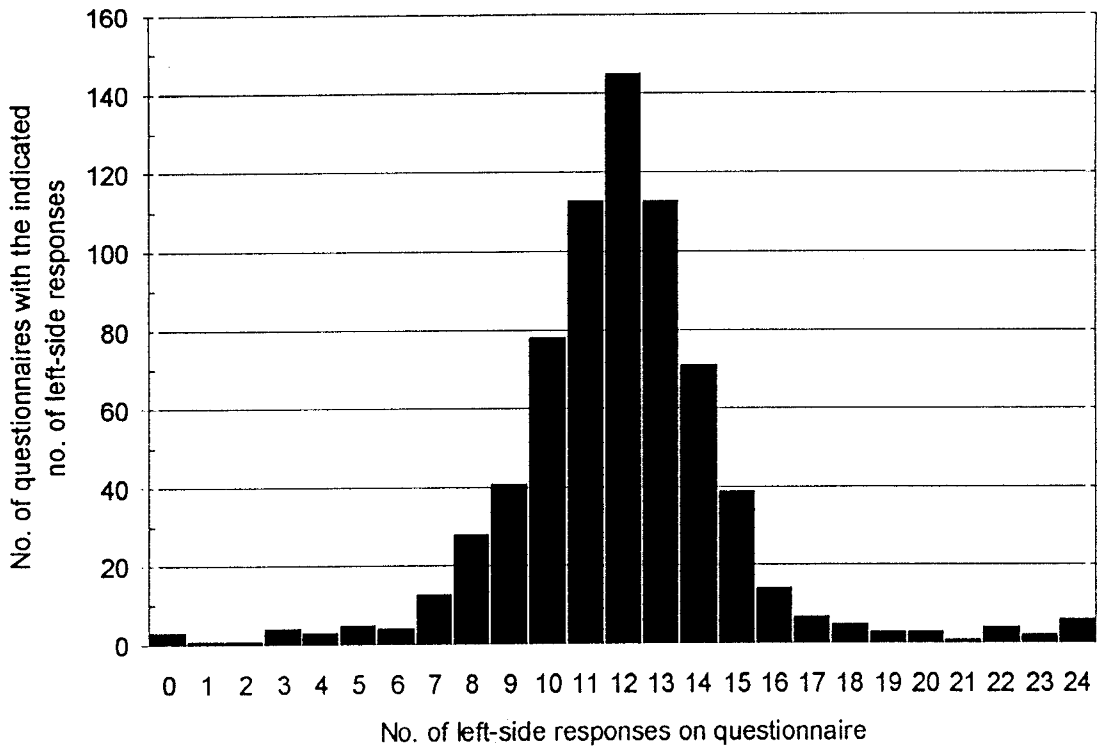

Figure 4.3.7a Distribution of respondents selecting the left-side response by question number

A X^2 test to determine whether the data were drawn from a binomial distribution with a probability of 50 per cent yielded a statistic of 86,6 with 13 degrees of freedom. This represents substantial evidence of a departure from the binomial distribution, but this was largely caused by the 9 respondents who selected all their responses from one side of the page, either from the left side or the right side only. Since such response patterns were relatively evenly balanced between the left and right sides, their influence on the findings was negligible and the identified departures from the expected distributions are not considered to be of any material significance.

The distribution of the number of environmental selections per questionnaire completed was also examined. Given the overall selection rate of 34,0 per cent for environmental factors, distribution of the number of responses selecting the environmental factor should be binomial with a probability of 34,0 per cent. Figure 4.3.7b illustrates the distribution for the number of environmental factor selections on each questionnaire.

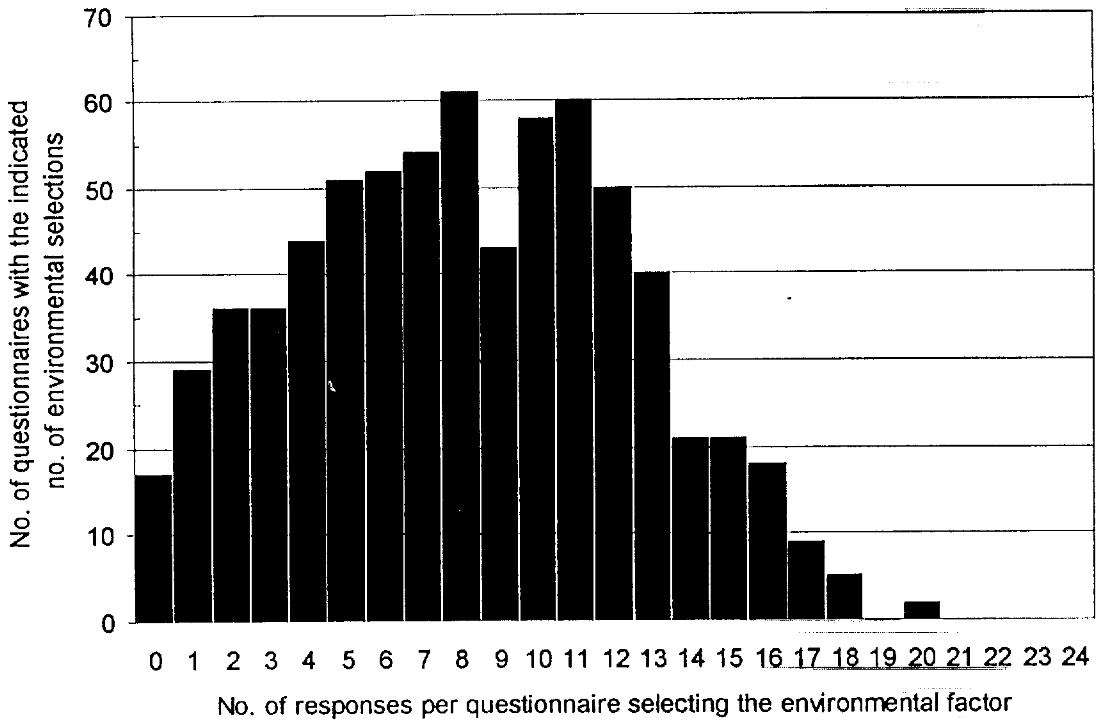

Figure 4.3.7b Distribution of respondents' identification of the environmental factor by question number

A X^2 test to determine whether a binomial distribution provides a satisfactory model produced a statistic of 1 636,6 with 11 degrees of freedom. The probability of obtaining such a value or greater is less than 0,1 per cent, and it is therefore concluded that the distribution is not binomial. This implies that certain respondents had a stronger than average tendency to identify the environmental factor, while others tended to select the non-environmental factor. This observation lends credibility to the results, as it indicates consistency in the opinions expressed by individual respondents.

4.3.8 Summary of findings of employee perception survey

The findings of the employee perception survey are summarized below in point form.

- Employees' responses to the paired comparisons between environmental and non-environmental factors revealed that underground employees in gold and platinum mines regard environmental factors to be of generally lesser importance as causes of accidents. An approximate quantification would be that environmental factors are perceived to be half as important as non-environmental factors.

- Employees identified visibility, noise, heat and ergonomics as the most important environmental factors, in that order. Ergonomics, in the current context, includes vibration and restricted space, while equipment ergonomics was treated indirectly, within the equipment & materials category.

- The degree of distinction among the various environmental factors is statistically significant but not substantial in terms of absolute magnitude. Visibility was regarded as having an importance of approximately 61 per cent, relative to the collective importance of all non-environmental factors, while the corresponding value for ergonomics was 44 per cent.

- No statistically significant differences in perceived importance could be identified among the non-environmental factors considered in the study, these being equipment & materials, standards & procedures, training & competency and management & supervision.

- While, on average, the four categories of non-environmental factors (i.e. equipment and materials, standards and procedures, training and competence, management and supervision) each attracted a similar overall importance rating, individual issues within each of these categories differed substantially in perceived importance.

- There is no evidence for any difference between workers from the gold mines and platinum mines included in the study regarding the perceived importance of environmental factors in accident occurrences.

- There is statistical evidence that environmental factors are regarded as more important by employees who work in stopes and development ends than by those working in the horizontal transport system and at other sites. The magnitude of the difference in perceived importance is small but applicable to each of the environmental factors considered.

- Similarly and no doubt related to the previous finding, there is evidence that workers in mining occupations regard environmental factors as more important contributors to accidents than do workers in engineering, transport and other occupations.

- Workers assign substantially greater importance to environmental factors than do supervisors and managers. Workers regard environmental factors to be 55 per cent as important as non-environmental factors, whereas supervisors and managers rate the importance of environmental factors as 28 per cent of that for non-environmental factors.

- The difference in opinion between workers and supervisors/managers is consistent for each environmental/non-environmental factor combination.

- There is no statistical evidence to indicate that mining experience influences employees' perceived importance of environmental factors in accident occurrences.

- Tests to examine the validity of the responses provided evidence of consistency in respondents' opinions, lending credibility to the results obtained and the conclusions drawn.

4.4 Summary of findings

Major findings of the current programme of work, summarized from the respective sections relating to the three principal sources of data, are presented below:

- Results of the accident investigations provided no evidence that environmental factors have a strong influence on accident rate. Among those environmental factors determined to be relevant, heat and confined space featured more prominently than noise and vibration, but the information submitted indicated a secondary role of environmental factors in the occurrence of accidents.

- While somewhat removed from the defined purpose of this work, it bears mentioning that the general tendency to limit accident investigations to a determination of the immediate cause may have its roots in a limited culture of root cause analysis. While employees. Whether such comments are valid becomes a moot issue where these perceptions exist and it would seem to follow that, where there is a lack of consensus regarding (in the current context) safety issues, decisions and actions taken to address them are likely to result in further disagreement and non-compliance. While structures have been put in place to enable a consultative approach in dealing with safety issues, it would appear that, in at least some instances, these are yet to be accepted as credible means of achieving consensus and moving forward.

Although accident investigations provided the least evidence for unfavourable environmental conditions having a negative influence on accident rate (in some instances even indicating the opposite), the apparent tendency to identify an immediate cause without considering underlying factors, combined with what, in some instances, seems to be a "defensive posture" in reporting environmental conditions, may have resulted in this element of the methodology underestimating the environment's indirect impact on safety.

The majority of the accident investigations considered identified human error in various forms as the principal cause of the accident, with most instances involving some deviation from safe work standards and procedures. This observation is consistent with *Heinrich's "dominos theory" (1931)* which states that 80 per cent of occupational accidents are caused by workers' unsafe acts. Unsafe behaviour and its underlying causes have received considerable attention during human factors/reliability studies and some have found that micro-organizational factors such as workgroup cohesiveness and cooperative workgroup/first-line supervisor relationships are the most important determinants of workers' compliance with safety rules *(e.g., Simard and Marchand, 1997:184)*. Where supervisors employ a participative approach to safety management involving workers in the formulation and critical review of safety rules, worker ownership and commitment have resulted in workgroup self-enforcement and greater compliance, i.e. a culture of safe work practice. The most important macro-organizational factor in achieving safety compliance was found to be a visible (to the workers) commitment to safety on the part of management.

It is the indirect nature of the environment's influence that has confounded efforts to quantify its role in accident occurrences, previously and during the current programme of work. While the literature has demonstrated productivity benefits of a favourable workplace environment, quantification of the safety benefits has proven more elusive and it must be stated that current efforts have not been entirely successful in expanding the understanding of these complex relationships. It is suggested that this need for improved understanding could best be addressed through workplace studies of human performance and error rate (both of which have potential impact on safety) under a variety of environmental conditions. The relatively infrequent occurrence of accidents in comparison to slips, lapses and "short-cuts" limits opportunities to acquire information from accident investigations but it must be acknowledged that the practicality of acquiring data in respect of the latter would be contingent on direct observation through a work-study approach.

The direct observation of performance and error rate suggested above has come from the realisation that the accumulation of accident data, in itself, has not proven entirely effective in quantifying the environment's impact on safety. Accordingly, it must be stated that no basis can be demonstrated for recommending an expansion of the current accident reporting system (e.g. DME Forms 10 and 11 in Appendix 3) to more directly include environmental factors. Greater benefit could be derived from a more uniform approach to the investigation of accidents with this process being undertaken by safety specialists, rather than the responsible line supervisors. In inspection of the various mine internal investigation forms in Appendix 3 are indicative of differing approaches and levels of follow-up from one mine to another.

Any environmental data collected in respect of accidents would be more beneficial if submitted with parallel normalizing data to enable correlations between distributions of environmental conditions and conditions at the time of accident occurrences. In this regard it must be realised that the task of gathering normalizing data and correlating it with those from accidents is an order of magnitude greater than simply collecting data on accidents and appropriate provision of resources would be required.

The development of qualitative insights into the root cause contribution to accidents by environmental and other factors would benefit from the use of "no-blame" accident investigations, once all issues of culpability have been resolved.

In terms of interventions to improve environmental conditions, the following suggestions are offered:

- Reconsider current practice with regard to heat stress, employing economic assessments and cost-benefit analyses as the bases for evaluating the safety (and productivity) benefits of reducing heat stress. This aspect of the environment appears to have the greatest potential for exerting indirect influence, particularly in terms of motivation and fatigue within the context of the shift work systems presently being adopted in the mining industry and that of plans to mine at greater depths.

- Reconsider present lighting standards, particularly in stopes, with cognisance of the potential for improved lighting to benefit the efficiency of all workplace tasks, most importantly, those with a bearing on safety.

The foregoing points notwithstanding, the principal focus of initiatives to reduce accident rates should be centred on non-environmental factors, particularly those relating to the observance of safe work standards. This may imply a need for greater efforts in the area of hazard awareness education, as well as the use of a more participative approach to safety management, including the formulation and critical review of safe work standards in order to establish and re-inforce worker commitment.

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APPENDIX 1 DATA ACQUISITION FORMS FOR ACCIDENT INVESTIGATIONS

SUPPLEMENTARY DATA TO BE RECORDED IN RESPECT OF REPORTABLE OR DISABLING INJURIES

Accidents normally occur as a result of a chain of undesirable events, the majority of which can be attributed to human error, or substandard acts or failure to act, as opposed to substandard conditions. The purpose of providing the information requested on this return is to gain a better understanding of those environmental factors which can make the possibility of human error more likely. The requested information is supplied on a confidential basis and will be employed only for research purposes. It may not and will not be used to assign individual or collective blame in any formal or informal accident investigation. Please also attach copies of the all relevant internal and DMEA investigation forms where applicable, as well as the results of any inquiry held.

THE SEQUENCE OF EVENTS LEADING UP TO THE ACCIDENT

No.[1]	Description of Event	Event Classification[2]	Time Before Accident (hh:mm)
1			
2			
3			
4			
5			
6			

Notes

18. Event number 1 should be the one which immediately resulted in the accident. Event number 2 should be the one which preceded event number 1, etc.

19. Events should be classified under the following headings;

A Equipment failure or other substandard condition
B Breach of procedure through inattentiveness or forgetfulness
C Conscious breach of procedure but with benevolent intent
D Conscious breach of procedure with malevolent intent
E Mistake or slip

ANALYSIS OF THE ENVIRONMENT UNDER WHICH THE EVENTS TOOK PLACE

(Not to be completed for classification A events)

This information relates to the environment to which the responsible mineworker was exposed prior to the event occurring. Please complete one form for each event classified B, C, D, or E.

Event Number: ________

		Actual	Subjective Assessment					Note
Wet-bulb temperature		____°C	A____	B____	C____	D____	E____	1
Dry-bulb temperature		____°C	A____	B____	C____	D____	E____	1
Wet kata reading		____	A____	B____	C____	D____	E____	1
Air velocity		____ m/s	A____	B____	C____	D____	E____	2
Witness perception of heat stress			A____	B____	C____	D____	E____	3
Noise level		____ dBA	A____	B____	C____	D____	E____	4
Witness perception of noise level			A____	B____	C____	D____	E____	3
Dust level		____ mg/m^3	A____	B____	C____	D____	E____	5
Dust count		____ p/ml	A____	B____	C____	D____	E____	5
Diesel fumes (particulate)		____ mg/m^3	A____	B____	C____	D____	E____	5
Diesel fumes (gaseous)	SO_2	____ ppm	A____	B____	C____	D____	E____	5
	NO_x	____ ppm	A____	B____	C____	D____	E____	5
	CO	____ ppm	A____	B____	C____	D____	E____	5
Carbon Dioxide level	CO_2	____ ppm	A____	B____	C____	D____	E____	5
Other gases or fumes	____	____ ppm	A____	B____	C____	D____	E____	5
Witness perception of air quality			A____	B____	C____	D____	E____	3
Illumination level		____ lux	A____	B____	C____	D____	E____	6
Witness perception of illumination level			A____	B____	C____	D____	E____	3
Witness perception of glare conditions			A____	B____	C____	D____	E____	3
Min. space available for movement		_____ cm	A____	B____	C____	D____	E____	7
Witness perception of unrestricted space available			A____	B____	C____	D____	E____	3

<u>Physiological attributes of the mineworker responsible for the event:</u>

Heat tolerance test results	A____	B____	C____	D____	E____	8
Audiometric test results	A____	B____	C____	D____	E____	8
Visual acuity test results	A____	B____	C____	D____	E____	8

<u>Prior exposure details</u>

Length of time since commencement of shift (hh:mm) ____________________

Time spent in working place where event occurred (hh:mm) ____________________

Comparative assessment of mine environment to which worker was previously exposed A____ B____ C____ D____ E____ 9

Were the environmental conditions cited as a direct cause of this event? ______________

Could the prevailing conditions have contributed indirectly to this event? ______________

If YES to either of the above, please indicate how:

____

____

Please refer to Page 3 for details of the Notes referred to above

NOTES ON COMPLETION OF PAGE 2 OF THIS RETURN

General

Where results of actual measurement of environmental conditions are available, please include them in the appropriate column.

In addition to the recording of such data, please also tick either A, B, C, D, or E relevant to each particular item.

Notes

1.	A: Cool	B: Warm	C: Hot	D: Very Hot	E: Intolerable
2.	A: High	B: Moderate	C: Acceptable	D: Low	E: Stagnant
3.	A: Excellent	B: Good	C: Acceptable	D: Poor	E: Unacceptable
4.	A: Quiet	B: Intermittent	C: Noticeable	D: Loud	E: Deafening
5.	A: Very Low	B: Low	C: Average	D: High	E: Very High
6.	A: Bright	B: Good	C: Acceptable	D: Dim	E: Nil or Very Low
7.	A: Not Applic.	B: Plenty	C: Reasonable	D: Cramped	E: Very Restricted
8.	A: Untested	B: Not Avail.	C: Above Avg.	D: Average	E: Below Average
9.	A: Much Better	B: Better	C: Similar	D: Worse	E: Much Worse

NAME OF PERSON COMPLETING THIS RETURN : ______________________________

DESIGNATION : ______________________________

TELEPHONE AND EXTENSION NUMBER : ______________________________

MANAGER'S SIGNATURE : ______________________________

RETURN ADDRESS

Please return all pages of this return to the following address;

The Project Leader: GAP203
CSIR Mining Technology
PO Box 91230
AUCKLAND PARK
2006

For the attention of Mr A.W. Nicoll, Projects Manager

PLEASE REMEMBER TO ATTACH COPIES OF ALL THE ACCIDENT INVESTIGATION FORMS AND, IF APPLICABLE, A COPY OF THE REPORTABLE ACCIDENT RETURN.

Thank you for your assistance in this important research project

SIMRAC GAP 203
Environmental Safety and Health
CSIR Division of Mining Technology
Occupational Hygiene Services

SUPPLEMENTARY INFORMATION IN RESPECT OF REPORTABLE ACCIDENTS

The purpose of this survey is to enable a better understanding of the extent to which environmental conditions and factors influence the occurrence of human errors that lead to accidents. **The information provided will be treated in strictest confidence** and will be employed for research purposes only, aimed at improving safety in gold and platinum mining. It may not and will not be used to assign individual or collective blame in any formal or informal investigation or report.

➔**In addition to the information recorded on the following pages, please attach copies of all relevant DMEA investigation forms including Form MD 16 A.**

➔**A separate data capture form should be completed for each accident, and copies of associated investigation forms attached.**

➔**Please be assured that all information provided will be treated in strictest confidence and will be used for research purposes only, in order to improve safety in gold and platinum mining. It WILL NOT be used to assign individual or collective responsibility in any formal or informal investigation or report, nor will it be attributed to any particular Mine or Group.**

➔Should you have any queries with respect to the completion of this data capture form or the information requested, please do not hesitate to contact us: Mike Franz on (011) 358-0071 or George Ashworth on -0036, or on -0000 (exchange).

1. ADMINISTRATIVE INFORMATION

Name of Mine: ____________________

Name and Designation of Individual Completing This Data Capture Form:

____

Telephone and Extension Number: ____________________

Signature: ____________________

➔Please return completed Data Capture Forms and copies of Form MD 16A to:

The Project Manager: GAP 203
Environmental Safety and Health
CSIR Division of Mining Technology
PO Box 91230
Auckland Park
2006 <u>**Attention: Mike Franz**</u>

or alternatively on Telefax No. (011) 482-3267.

2. ENVIRONMENTAL CONDITIONS

The information requested below relates to the Environmental Conditions prevailing at the location of the accident, both normally **AND** at the time of occurrence. For characterizing the "Normal" conditions, reference should be made to the mine's environmental records. For conditions at the time of occurrence, ask those present or involved in any way to give their subjective assessment of conditions prevailing at the time and indicate those perceptions by marking the appropriate boxes. Further information regarding the situation at the time of occurrence and actual values at the time of inspection are to be recorded in the spaces provided. The term "Employee" is generic and is not intended to distinguish between mine employees and contractors' employees, **i.e. "Employee" can refer to a mine employee, or to a contractor's employee (worker or supervisor).**

2.1 HEAT STRESS FACTORS:

2.1.1 Characterize the normal Level of Heat Stress/Temperature in the workplace where the accident occurred as compared with the average on the mine for that type of workplace, e.g. stope, development end, ore pass, box-hole, tip, station, haulage, cross-cut, etc:

☐ **Much Lower** ☐ **Lower** ☐ **Average** ☐ **Higher** ☐ **Much Higher**

2.1.2 Characterize the Level of Heat Stress/Temperature at the time of the accident as compared with the norm for that location **OR** for that employee:

☐ **Much Lower** ☐ **Lower** ☐ **Normal** ☐ **Higher** ☐ **Much Higher**

If different from Normal for that location or employee, identify the cause(s) of difference (e.g. ventilation problems, excess water, use of equipment or machinery not normally used there, fire, physical condition of employee i.e. recent illness, medication, inadequate heat acclimatization, recent transfer/re-allocation, substance abuse etc.):

____

____

2.1.3 Did the Overall Level of Heat Stress/Temperature change just before the accident as compared with what it had been?

☐ **No Change** ☐ **Decreased** ☐ **Increased**

If there was a change just before the accident, identify the cause(s) (e.g. ventilation change-over or failure, start-up or shut-down of equipment or machinery, ingress of water after an intersection, fire, any worker-related factors i.e. onset of heat stress, etc.):

____

____

2.1.4 Is Drinking Water normally available near the location of the accident? ☐ **Yes** ☐ **No**

2.1.4.1 Was Drinking Water available on the day of the accident? ☐ **Yes** ☐ **No**

If Drinking Water is normally available near the location of the accident and was not available on the day, indicate the cause(s)/reason(s) for the difference:

____

____

2.1.4.2 Distance to Nearest Source of Drinking Water at the time of the accident:

☐ **Less than 50 m** ☐ **50-100 m** ☐ **More than 100 m**

2.1.4.3 On the day of the accident and prior to its occurrence, did the employee drink water during the shift and how much did he drink?

☐ **More than 1 litre** ☐ **Less than 1 litre** ☐ **None**

2.1.5 Heat Stress-related values for location of accident at the time of inspection:

2.1.5.1 Date and Time of Inspection: ___________(dd/mm/yy) ________(hh:mm)

2.1.5.2 Wet-bulb Temperature: ________°C

2.1.5.3 Dry-Bulb Temperature: ________°C

2.1.5.4 Relative Humidity: ________%

2.1.5.5 Air Velocity: ________m/sec

2.1.5.6 Wet-Kata Reading: ________mCal/cm^2/sec

2.2 FACTORS INFLUENCING VISIBILITY:

2.2.1 Characterize the normal Visibility in the workplace where the accident occurred as compared with the average on the mine for that type of workplace:

☐**Much Greater** ☐**Greater** ☐**Average** ☐**Less** ☐**Much Less**

2.2.2 Characterize the Visibility at the time of the accident as compared with the norm for that location **OR** for that employee:

☐**Much Greater** ☐**Greater** ☐**Normal** ☐**Less** ☐**Much Less**

If different from Normal for that location or employee, identify the factor(s) involved in the difference (e.g. inadequate lighting, glare, dust, diesel emissions, fogging or misting from rockdrills, ANFEX powder in the air, smoke from a fire, employee's vision affected by lost/scratched/dirty/damaged/inappropriate eye protection or by his physical condition at the time, etc.): ____________________

2.2.3 Did the Visibility change just before the accident in comparison to what it had been?

☐**No Change** ☐**Increased** ☐**Decreased**

If there was a change just before the accident, identify the cause(s) (e.g. lighting failure, ventilation change-over or failure, start-up or shut-down of equipment or machinery, non-routine operation, worker-related factors i.e. foreign object/substance in eye, damaged/lost eye protection or substance abuse, etc.): ____________________

2.2.4 Eye Protection:

2.2.4.1 Was the employee using eye protection at the time of the accident? ☐ **Yes** ☐ **No**

2.2.4.2 Does employee regard the use **OR** lack of eye protection as a contributing factor?

☐ **Not at all** ☐ **Minor Contributor** ☐ **Major Contributor**

If use **OR** lack of eye protection was seen as a contributor, what type of protection was used?

☐ **Face Shield** ☐ **Plastic Goggles** ☐ **Gauze Goggles** ☐ **Safety Glasses** ☐ **None**

If use **OR** lack eye protection is regarded as a contributor, explain how it contributed:

____

____

____

____

2.2.4.3 Does the employee normally wear eye protection in situations similar to those in which the accident occurred?

☐ **Always** ☐ **Sometimes** ☐ **Rarely/Never**

2.2.5 Characterize the normal Level of Lighting in the workplace where the accident occurred as compared with the average on the mine for that type of workplace:

☐ **Much Brighter** ☐ **Brighter** ☐ **Average** ☐ **Dimmer** ☐ **Much Dimmer**

2.2.5.1 Specify number and type(s) of functional light sources in use at the time of the accident, including cap lamps:

____

____

____

____

2.2.6 Characterize the normal level of Noticeable Dust in the workplace where the accident occurred as compared with the average on the mine for that type of workplace:

☐ **Much Less** ☐ **Less** ☐ **Average** ☐ **More** ☐ **Much More**

2.2.7 Characterize the normal level of Noticeable Diesel Emissions in the workplace where the accident occurred as compared with the average on the mine for that type of workplace:

☐ **Much Less** ☐ **Less** ☐ **Average** ☐ **More** ☐ **Much More**

2.2.8 Visibility-related values for location of accident at the time of inspection:

2.2.8.1 Date and Time of Inspection: ___________(dd/mm/yy) ________(hh:mm)

2.2.8.2 Illuminance Level: _________lux

2.2.8.3 Dust Level: _________mg/m^3

2.3 NOISE:

2.3.1 Characterize the normal Noise Level in the workplace where the accident occurred as compared with the average on the mine for that type of workplace:

☐ **Much Quieter** ☐ **Quieter** ☐ **Average** ☐ **Louder** ☐ **Much Louder**

2.3.2 Characterize the Noise Level at the time of the accident as compared with the norm for that location **OR** for that employee:

☐ **Much Quieter** ☐ **Quieter** ☐ **Normal** ☐ **Louder** ☐ **Much Louder**

If there was a difference from Normal for that location or employee, identify the cause(s) (e.g. faulty/damaged equipment or machinery, non-routine activities in progress, use of equipment or machinery not normally used there, damaged/removed/disabled exhaust silencer/fan attenuator/acoustic enclosure, breakdown or inactivity of equipment/machinery normally used, or worker-related factors i.e. incorrect operation of machinery, lost/damaged hearing protectors, etc.): ____________________

____

2.3.3 Did the Noise Level change just before the accident in comparison to what it had been?

☐ **No Change** ☐ **Became Quieter** ☐ **Became Noisier**

If there was a change just before the accident, identify the cause(s) (e.g. start-up or shut-down of equipment/machinery, damage to equipment/machinery, or worker-related factors i.e. incorrect operation of equipment/machinery, lost/damaged hearing protectors, etc.):

____

____

2.3.4 Warning Signals:

2.3.4.1 Type(s) of Audible Warning Signal(s) available: ____________________

2.3.4.2 Was a warning signal activated? ☐ **Yes** ☐ **No**

If activated, was signal heard by employee? ☐ **Yes** ☐ **No**

2.3.5 Hearing Protection Devices (HPDs):

2.3.5.1 Was area of occurrence demarcated as a Noise Zone? ☐ **Yes** ☐ **No**

2.3.5.2 Was employee using HPDs at the time of the accident? ☐ **Yes** ☐ **No**

2.3.5.3 Does employee regard the use **OR** lack of HPDs as a contributing factor?

☐ **Not at all** ☐ **Minor Contributor** ☐ **Major Contributor**

If the use **OR** lack of HPDs is regarded as a contributor, what type of HPDs were used?

☐ **Plugs** ☐ **Band-mounted Plugs** ☐ **Muffs** ☐ **Custom-moulded Plugs** ☐ **None**

If use **OR** lack of hearing protection is regarded as a contributor, explain how it contributed:

____

____

2.3.5.4 Does the employee normally wear hearing protection in situations similar to those in which the accident occurred?

☐ **Always** ☐ **Sometimes** ☐ **Rarely/Never**

2.3.6 Noise Level at location of accident at the time of inspection: __________dB(A)

2.3.6.1 Date and Time of Inspection: ____________(dd/mm/yy) __________(hh:mm)

2.4 ERGONOMIC FACTORS:

2.4.1 Whole-body Vibration:

N.B. If there was no whole-body vibration evident at the time of the accident and that is normal for that work situation, the correct response to **2.4.1.1** would be "**Normal**".

2.4.1.1 How does the employee characterize the level of whole-body vibration at the time of the accident compared with the norm for that work situation **OR** for that employee:

☐**Much Less** ☐**Less** ☐**Normal** ☐**Greater** ☐**Much Greater**

If there was a difference from Normal for that situation or employee, identify the cause(s) (e.g. non-routine activities in progress, use of equipment or machinery not normally used there, use of damaged equipment/machinery, breakdown or inactivity of equipment or machinery normally used, any worker-related factors i.e. incorrect use of machinery etc.):

____

____

____

____

____

____

2.4.1.2 Did the level of whole-body vibration change just before the accident in comparison to what it had been?

☐**No Change** ☐**Became Less** ☐**Became Greater**

If there was a change just before the accident, identify the cause(s) (e.g. start-up or shut-down of equipment or machinery, damage to equipment/machinery or any worker-related factors i.e. incorrect operation of machinery etc.): ______________________________

____

____

____

____

____

____

2.4.2 Hand-arm Vibration:

N.B. If there was no hand-arm vibration evident at the time of the accident and that is normal for that work situation, the correct response to **2.4.2.1** would be "**Normal**".

2.4.2.1 How does the employee characterize the level of hand-arm-vibration at the time of the accident compared with the norm for that work situation **OR** for that employee:

☐ **Much Less** ☐ **Less** ☐ **Normal** ☐ **Greater** ☐ **Much Greater**

If there was a difference from Normal for that situation or employee, identify the cause(s) (e.g. non-routine activities in progress, use of equipment or machinery not normally used there, use of damaged equipment/machinery, breakdown or inactivity of equipment or machinery normally used, or any worker-related factors i.e. incorrect operation of machinery, lost or damaged protective equipment etc.): ______________________________

____

____

____

2.4.2.2 Did the level of hand-arm vibration change just before the accident in comparison to what it had been?

☐ **No Change** ☐ **Became Less** ☐ **Became Greater**

If there was a change just before the accident, identify the cause(s) (e.g. damage to equipment or machinery, start-up or shut-down of equipment or machinery, or any worker-related factors i.e. incorrect operation of machinery, lost or damaged protective equipment, etc.):

____

____

____

____

2.4.3 Space for Movement:

2.4.3.1 Characterize the normal Space for Movement where the accident occurred, as compared with the average on the mine for that type of workplace:

☐ **Much More** ☐ **More** ☐ **Average** ☐ **Less** ☐ **Much Less**

2.4.3.2 Space for Movement at the time of the accident as compared with the norm for that location, **OR** for that employee:

☐ **Much More** ☐ **More** ☐ **Normal** ☐ **Less** ☐ **Much Less**

If at the time of the accident there was a difference from the Normal, identify the cause(s) of the difference (e.g. presence of equipment/machinery not normally used there, absence of normal equipment/machinery, non-routine activities, any worker-related factors, etc.):

____

____

____

____

2.4.4 Space for Movement at the time of inspection:

2.4.4.1 Date and Time of Inspection: __________(dd/mm/yy) __________(hh:mm)

2.4.4.2 Space for movement:

Vertical: __________cm Lateral: __________ X __________cm

3. WORKER WHO MAY HAVE CAUSED / CONTRIBUTED TO THE ACCIDENT

Please complete this page and the following (Sections 3.1 to 3.5) for each employee (mine's or contractor's) who appears to have played a role in the occurrence of the accident.

3.1 Details of individual: N.B. Parentheses ( ) indicate optional informatin (may be omitted)

3.1.1 (Name): ______________________________

3.1.2 (Co./Ind. No): _______________

3.1.3 Age: ________

3.1.4 Occupation: _________________________

3.2 Role of individual:
Explain how this individual caused or contributed to the occurrence of the accident (or how his actions after the accident made matters worse, if applicable): _________________________

____

____

____

____

3.3 Time-and-Shift-related factors:

3.3.1 Experience in Occupation (yy:mm): __________

3.3.2 Experience where accident occurred (days/weeks/months): _____________

3.3.3 At the time of the accident, for how long had the employee been on duty:

☐ **<2 hours** ☐ **2 to 4 hours** ☐ **4 to 6 hours** ☐ **6 to 8 hours** ☐ **>8 hours**

3.3.4 Time spent that shift at location of accident prior to occurrence (hh:mm): ___________

3.3.5 Abnormal shifts: At the time of the accident, the employee:

☐ **Had had no deviation from a normal shift routine during the previous 48 hours**

☐ **Had changed or rotated shifts during the previous 48 hours**

☐ **Had worked a double shift during the previous 48 hours**

☐ **Was working the second shift of a double shift**

3.4 Physical Exertion

3.4.1 How does the employee characterize how strenuous his activities were prior to the occurrence of the accident, as compared with his normal activities:

☐ **Much Less** ☐ **Less** ☐ **Normal** ☐ **More** ☐ **Much More**

If there was any difference from the normal activities for that employee, describe his activities before the accident and identify the reason(s) for the difference (e.g. use of equipment or machinery not normally used there, breakdown/unavailability of normal equipment/machinery, manpower shortage, emergency, etc.): ___________________

____

____

____

3.5 Employee's Most Recent Test Results and Medical Factors:

3.5.1 Most recent HTT **OR** HTS: **Mark one only:**

Heat Tolerance Test (4-hour HTT): **OR:** Heat Tolerance Screening (30-min. HTS):

Heat Tolerance Test (4-hour HTT)	Heat Tolerance Screening (30-min. HTS)
☐ **Hyper-heat-tolerant**	☐ **Passed first attempt**
☐ **Intermediately-heat-tolerant**	☐ **Passed second attempt**
☐ **Low-heat-tolerant and completed CRA**	☐ **Passed third attempt**
☐ **Low-heat-tolerant but did not complete CRA**	☐ **Classified Grossly-heat-intolerant**
☐ **Untested/results not available**	☐ **Untested/results not available**

Department responsible for HTT/HTS:________________________

3.5.2 Most recent Hearing Test Results:

☐ **Category 1** (Normal)

☐ **Category 2** (Warning Level)

☐ **Category 3** (Referral Level) **and Referred to MMO**

☐ **Category 3 but Not Referred to MMO**

☐ **Untested/results not available**

Department responsible for Hearing Tests: ________________________

3.5.3 Most recent Vision Test Results:

3.5.3.1 Binocular Visual Acuity: Snellen score or equivalent:

☐ 6/6

☐ 6/9

☐ **6/12**

☐ **6/18 or worse OR either eye 6/36 or worse**

☐ **Untested/results not available**

3.5.3.2 Colour perception: Ishihara Test result:

☐ **Passed 6-plate test**

☐ **Passed 15-plate test**

☐ **Not tested: Not required for employee's occupation**

☐ **Failed Both 6-plate and 15-plate tests**

☐ **Test required for employee's occupation, but Not Tested**

Department responsible for Vision Tests: ________________________

3.5.4 Medical Factors:

3.5.4.1 Did the employee have any medical condition at the time of the accident?

☐ **None** ☐ **Treated Chronic** ☐ **Untreated Chronic** ☐ **Treated Acute** ☐ **Untreated Acute**

Indicate the nature of any medical condition from **3.5.4.1**, including whether medication was being administered at the time of the accident or, alternatively, whether normally administered medication was not being taken at the time:

____

____

____

____

____

APPENDIX 2 EMPLOYEE PERCEPTION SURVEY

CSIR DIVISION OF MINING TECHNOLOGY

SIMRAC GAP 203:

Possible Role of Environmental Factors in Causing or Contributing to Underground Accidents in Gold and Platinum Mining

EMPLOYEE PERCEPTION SURVEY

A. BACKGROUND INFORMATION

Please provide the information requested below:

1. What is your **PRESENT** Job Category/Occupation/Designation?

   ____

2. **WHERE** do you normally work?

   ☐ Surface ☐ Haulage or Crosscut

   ☐ Development end ☐ Tips or Station

   ☐ Stope ☐ Underground Workshop

   If none of the above, SPECIFY WHERE: ______________________

3. In **WHAT YEAR** did you start your Present Job? ______________________

4. What **OTHER JOBS** have you done **IN MINING?** ______________________

   ____

5. For **HOW MANY YEARS** have you **WORKED IN MINING?** ______________________

6. Have you ever witnessed or been involved in an underground accident?

   ☐ YES ☐ NO

   6a) If you witnessed or were involved in an underground accident, **WHAT do you think CAUSED THE ACCIDENT** to happen?

   ____

   ____

   6b) If you were involved in an underground accident,

   WERE YOU INJURED? ☐ YES ☐ NO

   If **YES, WHAT INJURY** did you suffer?

   ____

B. <u>INSTRUCTIONS FOR COMPLETING THIS QUESTIONNAIRE</u>

On the following two pages are statements about what can make accidents happen, with possible answers to complete the statement. The answers are in pairs: **two, two.**

- For each pair of answers **mark the answer that you think is better.** There are no wrong answers, but from each pair of possible answers you should **choose only the answer that you think is more correct.**

- For each pair of answers, **the more correct answer is the one that would be more likely to cause an accident.**

- Please make sure that each pair has one answer marked:
  <u>Do not skip any pairs.</u>

- Do not spend a long time thinking about your responses: The next two pages should take no more than 10 minutes to complete.

C. WHAT CAN CAUSE UNDERGROUND ACCIDENTS?

Accidents are more likely to happen OR can happen more easily:
MARK ONE CHOICE FROM EACH PAIR OF ANSWERS!

1.	☐ when the workplace is too hot.	☐ when supervisors enlist or bring in inexperienced or untrained workers to do a task or to help with a task.
2.	☐ when workers do not know how to do the task they are busy with.	☐ when there is not enough space or room to work.
3.	☐ when workers do not understand the correct procedures or the standard they are meant to be working to.	☐ when machinery shakes too much, making it difficult to control.
4.	☐ when equipment is not properly maintained or not serviced when it is supposed to be.	☐ when the workplace is too hot.
5.	☐ when supervisors do not check the job and instruct or advise workers.	☐ when there is too much noise for people to communicate or hear warning signals.
6.	☐ when there is too much noise for people to communicate or hear warning signals.	☐ when people ignore standards and safety procedures or take short-cuts.
7.	☐ when workers do not have or do not use the correct safety or protective equipment.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.
8.	☐ when there is not enough space or room to work.	☐ when there are not enough workers to do the job.
9.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.	☐ when workers do not know about hazards and how to avoid them.
10.	☐ when doing the job according to standard would require too much work, and people take short-cuts.	☐ when the workplace is too hot.
11.	☐ when the workplace is too hot.	☐ when machinery is giving trouble or not working properly.
12.	☐ when there is too much noise for people to communicate or hear warning signals.	☐ when workers are sick or unfit or tired.

C. WHAT CAN CAUSE UNDERGROUND ACCIDENTS? (continued)

Accidents are more likely to happen OR can happen more easily:
MARK ONE CHOICE FROM EACH PAIR OF ANSWERS!

13.	☐ when machinery shakes too much, making it difficult to control.	☐ when work is done without using safe work practices.
14.	☐ when workers do not have the correct materials or equipment for the job.	☐ when there is too much noise for people to communicate or hear warning signals.
15.	☐ when supervisors have not told workers what they should do, or how they should do it.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.
16.	☐ when workers are new to the job or have not had much experience.	☐ when the workplace is too hot.
17.	☐ when working according to standard is not practical or takes too much time, and people take short-cuts.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.
18.	☐ when there is too much noise for people to communicate or hear warning signals.	☐ when workers do not understand the supervisor's instructions.
19.	☐ when the workplace is too hot.	☐ when workers have been drinking alcohol or smoking dagga.
20.	☐ when equipment is used incorrectly, or in an unsafe manner.	☐ when there is too much noise for people to communicate or hear warning signals.
21.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.	☐ when machinery has no safety guards, or the safety guards are faulty.
22.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.	☐ when supervisors do not check to see that work is done according to standard.
23.	☐ when there is not enough space or room to work.	☐ when workers have not had proper training or refresher training for the job they are doing.
24.	☐ when hazardous chemicals or dangerous materials are being used.	☐ when machinery shakes too much, making it difficult to control.

C. WHAT CAN CAUSE UNDERGROUND ACCIDENTS?

Accidents are more likely to happen OR can happen more easily:
MARK ONE CHOICE FROM EACH PAIR OF ANSWERS!

1.	☐ when there is too much noise for people to communicate or hear warning signals.	☐ when supervisors enlist or bring in inexperienced or untrained workers to do a task or to help with a task.
2.	☐ when the workplace is too hot.	☐ when workers do not know how to do the task they are busy with.
3.	☐ when the workplace is too hot.	☐ when workers do not understand the correct procedures or the standard they are meant to be working to.
4.	☐ when equipment is not properly maintained or not serviced when it is supposed to be.	☐ when there is too much noise for people to communicate or hear warning signals.
5.	☐ when there is not enough space or room to work.	☐ when supervisors do not check the job and instruct or advise workers.
6.	☐ when people ignore standards and safety procedures or take short-cuts.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.
7.	☐ when workers do not have or do not use the correct safety or protective equipment.	☐ when machinery shakes too much, making it difficult to control.
8.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.	☐ when there are not enough workers to do the job.
9.	☐ when workers do not know about hazards and how to avoid them.	☐ when the workplace is too hot.
10.	☐ when doing the job according to standard would require too much work, and people take short-cuts.	☐ when there is too much noise for people to communicate to hear warning signals.
11.	☐ when there is too much noise for people to communicate or hear warning signals.	☐ when machinery is giving trouble or not working properly.
12.	☐ when workers are sick or unfit or tired.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.

C. WHAT CAN CAUSE UNDERGROUND ACCIDENTS? (continued)

Accidents are more likely to happen OR can happen more easily:
MARK ONE CHOICE FROM EACH PAIR OF ANSWERS!

13.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.	☐ when work is done without using safe work practices.
14.	☐ when machinery shakes too much, making it difficult to control.	☐ when workers do not have the correct materials or equipment for the job.
15.	☐ when supervisors have not told workers what they should do, or how they should do it.	☐ when there is not enough space or room to work.
16.	☐ when workers are new to the job or have not had much experience.	☐ when there is too much noise for people to communicate or hear warning signals.
17.	☐ when there is too much noise for people to communicate or hear warning signals.	☐ when working according to standard is not practical or takes too much time, and people take short-cuts.
18.	☐ when the workplace is too hot.	☐ when workers do not understand the supervisor's instructions.
19.	☐ when workers have been drinking alcohol or smoking dagga.	☐ when machinery shakes too much, making it difficult to control.
20.	☐ when there is not enough space or room to work.	☐ when equipment is used incorrectly or in an unsafe manner.
21.	☐ when machinery has no safety guards, or the safety guards are faulty.	☐ when the workplace is too hot.
22.	☐ when supervisors do not check to see that work is done according to standard.	☐ when the workplace is too hot.
23.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.	☐ when workers have not had proper training or refresher training for the job they are doing.
24.	☐ when hazardous chemicals or dangerous materials are being used.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.

C. WHAT CAN CAUSE UNDERGROUND ACCIDENTS?

Accidents are more likely to happen OR can happen more easily:
MARK ONE CHOICE FROM EACH PAIR OF ANSWERS!

1.	☐ when supervisors enlist or bring in inexperienced or untrained workers to do a task or to help with a task.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.
2.	☐ when there is too much noise for people to communicate or hear warning signals.	☐ when workers do not know how to do the task they are busy with.
3.	☐ when there is too much noise for people to communicate or hear warning signals.	☐ when workers do not understand the correct procedures or the standard they are meant to be working to.
4.	☐ when there is not enough space or room to work.	☐ when equipment is not properly maintained or not serviced when it is supposed to be.
5.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.	☐ when supervisors do not check the job and instruct or advise workers.
6.	☐ when people ignore standards and safety procedures or take short-cuts.	☐ when there is not enough space or room to work.
7.	☐ when the workplace is too hot.	☐ when workers do not have or do not use the correct safety or protective equipment.
8.	☐ when there are not enough workers to do the job.	☐ when the workplace is too hot.
9.	☐ when workers do not know about hazards and how to avoid them.	☐ when there is too much noise for people to communicate or hear warning signals.
10.	☐ when there is not enough space or room to work.	☐ when doing the job according to standard would require too much work, and people take short-cuts.
11.	☐ when machinery is giving trouble or not working properly.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.
12.	☐ when workers are sick or unfit or tired.	☐ when machinery shakes too much, making it difficult to control.

C. WHAT CAN CAUSE UNDERGROUND ACCIDENTS? (continued)

Accidents are more likely to happen OR can happen more easily:
MARK ONE CHOICE FROM EACH PAIR OF ANSWERS!

13.	☐ when work is done without using safe work practices.	☐ when the workplace is too hot.
14.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.	☐ when workers do not have the correct materials or equipment for the job.
15.	☐ when the workplace is too hot.	☐ when supervisors have not told workers what they should do, or how they should do it.
16.	☐ when machinery shakes too much, making it difficult to control.	☐ when workers are new to the job or have not had much experience.
17.	☐ when working according to standard is not practical or takes too much time, and people take short-cuts.	☐ when the workplace is too hot.
18.	☐ when workers do not understand the supervisor's instructions.	☐ when machinery shakes too much, making it difficult to control.
19.	☐ when workers have been drinking alcohol or smoking dagga.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.
20.	☐ when it is difficult to see, because it is too dark or there is too much dust or fog.	☐ when equipment is used incorrectly or in an unsafe manner.
21.	☐ when machinery has no safety guards, or the safety guards are faulty.	☐ when there is too much noise for people to communicate or hear warning signals.
22.	☐ when supervisors do not check to see that work is done according to standard.	☐ when there is too much noise for people to communicate or hear warning signals.
23.	☐ when workers have not had proper training or refresher training for the job they are doing.	☐ when the workplace is too hot.
24.	☐ when there is too much noise for people to communicate or hear warning signals.	☐ when hazardous chemicals or dangerous materials are being used.

WNNR MYNBOUTEGNOLOGIE

SIMRAC GAP 203:

"Moontlike Rol van Omgewingsfaktore as Oorsaak of Meewerkende Faktore wat Aanleiding gee tot Ondergrondse Ongelukke in Goud-en Platinamyne"

WERKNEMERS PERSEPSIE OPNAME

A. AGTERGRONDSINLIGTING

Voorsien asseblief die volgende inligting:

1. Wat is u **HUIDIGE** Werkskategorie/Beroep/Posbenaming?

   ____

2. **WAAR** is u normale werksplek?

   ☐ Bogronds ☐ Haulage of X-Cut

   ☐ Ontwikkeling ☐ Tips of Stasie

   ☐ Stope ☐ Werkswinkel Ondergronds

   Indien nie een van bogemonde, SPESIFISEER WAAR: ______________

3. In **WATTER JAAR** het u die Huidige Werk begin doen? ______________

4. Watter **ANDER WERK/POSTE** het u **IN DIE MYNWESE** bekleë? ______________

   ____

5. **HOE LANK** (aantal jare) is u reeds in die **MYNWESE WERKSAAM?** ______________

6. Was u ooit getuie van, of betrokke by 'n ondergrondse ongeluk? ☐JA ☐NEE

   6a) Indien u getuie of betrokke was in 'n ondergrondse ongeluk, **WAT het na u mening die ONGELUK VEROORSAAK?**

   ____

   ____

   6b) Indien u by 'n ondergrondse ongeluk betrokke was

   WAS U BESEER? ☐JA ☐NEE

   Indien JA, **WATTER BESERINGS** het u gehad?

   ____

B. <u>INSTRUKSIES OM DIE VRAELYS TE VOLTOOI</u>

Op die hieropvolgende bladsye is stellings aangaande die oorsake van ongelukke met moontlike antwoorde om die stellings te voltooi. **Die antwoorde is in pare.**

- Kies die antwoord wat na u mening die beste is uit elke paar. Daar is nie verkeerde antwoorde nie. Uit elke paar **behoort u slegs die antwoord te kies wat meer korrek is.**

- Die **mees korrekte antwoord** is die een uit die paar wat heel waarskynlik **meer geneig sal wees om die ongeluk te veroorsaak.**

- Maak seker dat u by elke stelling een moontlikheid kies en merk: **<u>Moenie een van die pare oorslaan nie.</u>**

- Moenie lank oor u keuse tob nie. Dit behoort u nie langer as 10 minute te neem om die vraelys te voltooi nie.

C. WAT KAN ONDERGRONDSE ONGELUKKE VEROORSAAK?

Ongelukke is meer geneig om to gebeur of kan makliker gebeur:
MERK EEN VAN ELKE PAAR!

1.	☐ wanneer die werksomgewing te warm is.	☐ wanneer toesighouers onervare of onopgeleide werkers betrek om 'n taak te verrig of om te help om die taak te verrig.
2.	☐ wanneer werkers nie weet hoe om die taak, waarmee hulle besig, is uit te voer nie.	☐ wanneer daar te min spasie is om in te werk.
3.	☐ wanneer werknemers nie die korrekte prosedures en standaarde, waarvolgens hulle behoort te werk, verstaan nie.	☐ wanneer masjienerie te veel skud om na behore te beheer.
4.	☐ wanneer toerusting nie behoorlik onderhou word en nie gereeld gediens word nie.	☐ wanneer die werksomgewing te warm is.
5.	☐ wanneer toesighouers nie die werk kontroleer en werkers van instruksies en/of advies voorsien nie.	☐ wanneer daar te veel geraas is vir mense om met mekaar te kommunikeer of om gevaarseine te hoor.
6.	☐ wanneer daar te veel geraas is vir mense om met mekaar te kommunikeer of om gevaarseine te hoor.	☐ wanneer werkers standaarde en veilige werksprosedures verontagsaam en kortpad kies.
7.	☐ wanneer werkers nie die korrekte veiligheidstoerusting het of gebruik nie.	☐ wanneer dit moeilik is om te sien omdat dit te donker is of omdat daar te veel stof of vog is.
8.	☐ wanneer daar te min spasie is om in te werk.	☐ wanneer daar nie voldoende werkers is om die taak te verrig nie.
9.	☐ wanneer dit moeilik is om te sien omdat dit te donker is of omdat daar te veel stof of vog is.	☐ wanneer werkers nie bewus is van gevare nie en ook nie weet hoe om die gevare te vermy nie.
10.	☐ wanneer dit te veel werk behels om volgens standaarde te werk en werknemers kortpad kies.	☐ wanneer die werksomgewing te warm is.
11.	☐ wanneer die werksomgewing te warm is.	☐ wanneer masjienerie nie behoorlik werk nie.
12.	☐ wanneer daar te veel geraas is vir mense om met mekaar te kommunikeer of om gevaarseine te hoor.	☐ wanneer werkers siek, onfiks of moeg is.

C. WAT KAN ONDERGRONDSE ONGELUKKE VEROORSAAK?

Ongelukke is meer geneig om to gebeur of kan makliker gebeur:
MERK EEN VAN ELKE PAAR!

13.	☐ wanneer masjienerie te veel skud om na behore te beheer.	☐ wanneer werk gedoen word sonder dat veilige werksprosedures gehandhaaf word.
14.	☐ wanneer werkers nie die korrekte materiaal en toerusting vir die taak het nie.	☐ wanneer daar te veel geraas is vir mense om met mekaar te kommunikeer of om gevaarseine te hoor.
15.	☐ wanneer toesighouers nie aan die werkers verduidelik **wat** hulle behoort te doen en **hoe** die taak gedoen behoort te word nie.	☐ wanneer dit moeilik is om te sien omdat dit te donker is of omdat daar te veel stof of vog is.
16.	☐ wanneer werkers pas met die taak begin het of nog min ondervinding het.	☐ wanneer die werksomgewing te warm is.
17.	☐ wanneer dit onprakties is of dit te lank neem om volgens standaarde te werk en werknemers kortpad kies.	☐ wanneer dit moeilik is om te sien omdat dit te donker is of omdat daar te veel stof of vog is.
18.	☐ wanneer daar te veel geraas is vir mense om met mekaar te kommunikeer of om gevaarseine te hoor.	☐ wanneer werknemers nie die toesighouer se instruksie verstaan nie.
19.	☐ wanneer die werksomgewing te warm is.	☐ wanneer werkers alkohol gedrink het of dagga gerook het.
20.	☐ wanneer toerusting verkeerdelik of onveilig gebruik word.	☐ wanneer daar te veel geraas is vir mense om met mekaar te kommunikeer of om gevaarseine te hoor.
21.	☐ wanneer dit moeilik is om te sien omdat dit te donker is of omdat daar te veel stof of vog is.	☐ wanneer masjienerie nie van veiligheidskerms voorsien is nie of wanneer die veiligheidskerms foutief is.
22.	☐ wanneer dit moeilik is om te sien omdat dit te donker is of omdat daar te veel stof of vog is.	☐ wanneer toesighouers nie kontroleer om toe te sien dat werk volgens die standaard gedoen word nie.
23.	☐ wanneer daar te min spasie is om in te werk.	☐ wanneer werkers nie na behore opgelei is nie of verfrissingsopleiding, vir die taak waarmee hulle besig is, ontvang het nie.
24.	☐ wanneer gevaarlike chemikalieë of materiale gebruik word.	☐ wanneer masjienerie te veel skud om na behore te beheer.

CSIR DIVISION OF MINING TECHNOLOGY
SIMRAC GAP 203:

"Possible Role of Environmental Factors in Causing or Contributing to Underground Accidents in Gold and Platinum Mining"

EMPLOYEE PERCEPTION SURVEY

A. BACKGROUND INFORMATION

Okgopelwa go re o fe tshedimošetšo ye e latelago mo:

1. Na lefapha la mošomo wa gago ke lefe / mošomo wa gago ke fe / maemo a gago ke afe?

   ____

2. Na o šomela **KAE** ka mehla?

   ☐ Surface ☐ Haulage or X-Cut

   ☐ Development end ☐ Tips or Station

   ☐ Stope ☐ Underground Workshop

   Ge o sa šome go le lengwe la mafelo a mo godimo, HLATHOLLA GORE KE KAE.

   ____

3. O thomile **KA NGWAGA O FE** go šoma mošomo wo? ______________

4. Ke **MEŠOMO EFE E MENGWE** o e šommego **MO MMAINENG?** ______________

   ____

5. **O ŠOMME MENGWAGA E MEKAE MO MMAINENG?** ______________

6. Na o ile wa ke wa bona goba wa amega kotsing ya ka Mmaineng?

   ☐ EE ☐ AOWA

   6a) Ge o ile wa ke wa bona goba wa amega kotsing ya ka mmaineng, **KE ENG se o naganago gore SE HLOTŠE GORE KOTSI** e derege?

   ____

   ____

   6b) **O ILE WA GOBALA?** ☐ EE ☐ AOWA

   Ge karabo e le EE, **KGOBALO** ya gago e ile ya ba efe?

   ____

B. DITAELO TŠA GO TLATŠA/GO ARABA DIPOTŠIŠO

Mo matlakaleng a mabedi go nale di statamente mabapi le seo se ka hlolago kotsi, le dikarabo tšeo di tlogo feleletša di statamente tšeo. Dikorabo di sepela di le **tše pedi, tše pedi.**

- Mo dikarabong tše dingwe le tše dingwe tše pedi, kgetha yeo o bonago e le e kaone. Ga go karabo e fošagetseng, eupša mo **dikarabong o swanetše go kgetha e o naganago gore e lokile.**

- Mo di karabong; **yeo e lokilego ke eo go ya ka wena, e ka hlolago kotsi.**

- Dira gore o kgethe karabo e tee. **O se ke wa tshela dikarabo tše dingwe.**

- O se ke wa senya nako e ntši o nagana. Matlakala a mabedi a a latelago ga a swanela go go tšea lebaka le le fetago metsotso e lesome.

C. KE ENG SEO SE KA HLOLAGO KOTSI KA MMAINENG?

Dikotsi gantŝi dia direga/di ka direga bonolo:

KGETHA E TEE GOTŠWA GO TŠE DINGWE LE TŠE DINGWE TŠE PEDI!

1	☐	Ge lefelo la go ŝomela le fiŝa ka kudu.	☐	Ge bahlokomedi ba tliŝa batho bao ba sena go maitemogelo goba ba se ba hlahlwa gore ba tle ba thuŝe ka se sengwe.
2	☐	Ge baŝomi ba sa tsebe selo ka ga moŝomo o ba o dirago.	☐	Ge lefelo la go ŝomela e le le le nnyane.
3	☐	Ge bošomi ba sa kwišiši gabotse lenanego goba melao yeo ba swanetšego go e latela ge ba šoma.	☐	Ge metŝhene e ŝikinyega ka kudu, gore e pale go laolega.
4	☐	Ge sedirišwa se sa hlokomelwe ka tshwanelo goba se sa lekolwe ka nako e e swanetšego.	☐	Ge lefelo la go ŝomela le fiŝa ka kudu.
5	☐	Ge bahlokomedi ba sa lekole moŝomo le go eletŝa baŝomi.	☐	Ge go nale leŝata le lentŝi gore batho ba kakgona go kwana goba gokwa medumo ya temoŝo.
6	☐	Ge go nale leŝata le lentŝi gore batho ba kakgona go kwana goba gokwa medumo ya temoŝo.	☐	Ge batho ba sa latele melao, mananego a šireletšegilego goba ba kgaoletsa.
7	☐	Ge baŝomi ba se na goba ba sa šomiše dišireletšo tša maleba goba ditlabakelo tša go itshireletša.	☐	Ge o sa bone gabotse; ka lebaka le leswiswi goba go tletŝe lerole goba mogodi.
8	☐	Ge lefelo la go ŝomela e le le le nnyane.	☐	Ge go se na baŝomi ba ba lekanego go phetha moŝomo.
9	☐	Ge o sa bone gabotse; ka lebaka le leswiswi goba go tletŝe lerole goba mogodi.	☐	Ge baŝomi ba sa tsebe selo ka ga kotsi e e ka ba tlelago le gore ba ka phema kotsi bjang.
10	☐	Ge go dira moŝomo ka go latela melao go ka nyaka nako e ntši, le gona batho ba kgaoletša.	☐	Ge lefelo la go ŝomela le fiŝa ka kudu.
11	☐	Ge lefelo la go ŝomela le fiŝa ka kudu.	☐	Ge motŝhene o na le bothata goba o sa ŝome gabotse.
12	☐	Ge go nale leŝata le lentŝi gore batho ba kakgona go kwana goba gokwa medumo ya temoŝo.	☐	Ge baŝomi ba babja goba ba lapile goba ba se ba etekanela.

C. KE ENG SEO SE KA HLOLAGO KOTSI KA MMAINENG?

Dikotsi gantŝi dia direga/di ka direga bonolo:

KGETHA E TEE GOTŠWA GO TŠE DINGWE LE TŠE DINGWE TŠE PEDI!

13	☐	Ge metŝhene e ŝikinyega ka kudu, gore e pale go laolega.	☐	Ge mošomo o dirwa ka ntle ga go latela mekgwa ya go šoma ye e ŝireletŝegilego.
14	☐	Ge bašomi ba se na le ditlabakelo goba didirišwa tša mošomo.	☐	Ge go nale leŝata le lentŝi gore batho ba kakgona go kwana goba gokwa medumo ya temoŝo.
15	☐	Ge bahlokomedi ba sa botŝe baŝomi seo ba swanetŝego go be ba sedira goba ba sedire bjang.	☐	Ge o sa bone gabotse; ka lebaka le leswiswi goba go tletŝe lerole goba mogodi.
16	☐	Ge bašomi e le ba baswa goba ba sena maitemogelo.	☐	Ge lefelo la go ŝomela le fiŝa ka kudu.
17	☐	Ge go šoma ka maleba o latela melao go sa kgonege go ba go tšea nako entši, batho ba tsea tšela tše kopana (ba a kgaoletša).	☐	Ge o sa bone gabotse; ka lebaka le leswiswi goba go tletŝe lerole goba mogodi.
18	☐	Ge go nale leŝata le lentŝi gore batho ba kakgona go kwana goba gokwa medumo ya temoŝo.	☐	Ge baŝomi ba sa kwiŝiŝi ditaelo tŝa mohlokomedi.
19	☐	Ge lefelo la go ŝomela le fiŝa ka kudu.	☐	Ge baŝomi ba nwele bjala goba ba kgogile lebake.
20	☐	Ge sedirišwa se šomišwa bošaedi goba ka mokgwa wo fošagetšego.	☐	Ge go nale leŝata le lentŝi gore batho ba kakgona go kwana goba gokwa medumo ya temoŝo.
21	☐	Ge o sa bone gabotse; ka lebaka le leswiswi goba go tletŝe lerole goba mogodi.	☐	Ge motšhene o se na dišireletŝa-kotsi goba di šireletša-kotsi di na le phošo.
22	☐	Ge o sa bone gabotse; ka lebaka le leswiswi goba go tletŝe lerole goba mogodi.	☐	Ge bahlokomedi ba sa lekole gobona ge moŝomo o dirwa go ya le ka melao.
23	☐	Ge lefelo la go ŝomela e le le le nnyane.	☐	Ge baŝomi ba se na tlhahlo ya maleba goba tlhahlo-kgakollwa mo moŝomong o ba o dirago.
24	☐	Ge di khemikhale tše šoro goba didirišwa tše šoro di šomišwa.	☐	Ge metŝhene e ŝikinyega ka kudu, gore e pale go laolega.

CSIR DIVISION OF MINING TECHNOLOGY
SIMRAC GAP 203:

"Possible Role of Environmental Factors in Causing or Contributing to Underground Accidents in Gold and Platinum Mining"

EMPLOYEE PERCEPTION SURVEY

A. BACKGROUND INFORMATION

O kopja ho fana ka tshelimoso e lateng:

1. Na lefapha la mosebetsi wa hao ke lefe / mosebetsi wa hao ke ofe / maemo a hao ke afe?

   ____

2. Naa o sebeletsa **KAE** ka mehla?

   ☐ Surface ☐ Haulage or X-Cut

   ☐ Development end ☐ Tips or Station

   ☐ Stope ☐ Underground Workshop

   Haeba o sa sebetsi go enngwe ya ditulo tse umakiloeng, FANA KA THLALOSO HORE KE MO KAE:

   ____

3. O qadile **NENG** ho sebetsa mosebetsi o na? ______________

4. Ke **MESEBETSI E FE E MENGWE** ye o e sebeditseng **MO MMAINENG?**________

   ____

5. **O SEBEDITSE DILEMO DI LE KAE MO MMAINENG?** ______________

6. Na o kile wa <u>bona kampa wa ameha mo kotsing ya morafong</u>?

   ☐ EE ☐ NYAA

   6a) Haeba o kile wa <u>bona kampa wa ameha mo kotsing ya morafong</u>, **KE ENG se o nahanang hore SE KA BO SE HLOLILE KOTSI hore e etsahale?**

   ____

   6b) **NA OILE WA LEMALA?** ☐ EE ☐ NYAA
   Ha karabo ya hao e le EE; **HOLEMALA** ha hao e bile go **FE?**

   ____

B. DITAELO TSA HO ARABA DIPOTSISO.

Mo matlakaleng a mabedi ho na le di statamente tebang le seo se ka bakaang kotsi, le diphetolo tseo di tlaho qetelela di statamente tseo. Diphetolo di tsamaea di le **tse pedi, tse pedi.**

- Mo phetholong tse dingwe le tse dingwe tse pedi, khetha eo o bonang e le e kaone. Ha ho phetolo e fosahetseng, empa mo **diphetolong o swanela go khetha eo nahanang hore e lokile.**

- Mo di phetolong, **yeo e lokileng ke eo go ya ka oena, e ka bakang kotsi.**

- Etsa hore o khethe phetolo e nngwe feela. **O se ke oa taboha phetolo tse dingwe.**

- O se senye nako e telle o nahana. Matlakala a mabedi ao a latelang ha ea swanela ho ho nka nako e telele ho feta metsotso e lesome.

C. KE ENG SE SE KA BAKAANG KOTSI MO MMAINENG /MORAFONG? Dikotsi ha ngata dia etsahala/di ka etsahala ha bonolo: Khetha ENNGWE mo ho tse DINGWE LE TSE DINGWE TSE PEDI!

1.	☐	Ha tulo ya ho sebeletsa e tshesa haholo.	☐	Ha baokameli ba tlisa batho bao ba se nang temoho kampa ba se ba rupelloa, hore ba thuse ka mosebetsi.
2.	☐	Ha basebetsi ba sa tsebe letho ka mosebetsi o ba o etsang.	☐	Ha tulo ya ho sebeletsa e le e nnyenyane.
3.	☐	Ha basebetsi ba sa utlwisisi hantle lenaneo kampa melao eo ba soaneloang ke ho e sala moraho.	☐	Ha metjene e sisinyeha thatha hore e sitwe ho laoleha.
4.	☐	Ha sesebedisoa se sa tlhokomeloe ka tshwanno kampa se sa lekoloe ka nako eo e swanetseng.	☐	Ha tulo ya ho sebeletsa e tshesa haholo.
5.	☐	Ha baokameli ba sa lebelle mosebetsi le ho eletsa basebetsi.	☐	Ha ho nale lerata le lengata ho sitisa batho go utloana kampa ho utloa medumo ya temoso.
6.	☐	Ha ho nale lerata le lengata ho sitisa batho go utloana kampa ho utloa medumo ya temoso.	☐	Ha batho ba sa latele melao, mananeo ao a sireletsehileng kampa ba tsaea litsela tse kgusoane.
7.	☐	Ha basebetsi ba se na kampa ba sa sebedise dithibela-kotsi tsa nnete kampa ditlabakelo tsa ho itshireletsa.	☐	Ha o sa bone hantle; ka lebaka la lesufi kampa ho tletse lerule kampa mouwane.
8.	☐	Ha tulo ya ho sebeletsa e le e nnyenyane.	☐	Ha basebetsi ba se bakae ho phethahatsa mosebetsi.
9.	☐	Ha o sa bone hantle; ka lebaka la lesufi kampa ho tletse lerule kampa mouwane.	☐	Ha basebetsi ba sa tsebe letho ka ha kotsi eo e ka hlahang kampa ba ka phema jaang kotsi eo.
10.	☐	Ha ho etsa mosebetsi ka ho latela melao ho ka batla nako e telele le hona batho ba tsaea tsela tse khusoane.	☐	Ha tulo ya ho sebeletsa e tshesa haholo.
11.	☐	Ha tulo ya ho sebeletsa e tshesa haholo.	☐	Ha motjene o na le bothata kampa o sa sebetse hantle.
12.	☐	Ha ho nale lerata le lengata ho sitisa batho go utloana kampa ho utloa medumo ya temoso.	☐	Ha basebetsi ba kula kampa ba kgathetse.

C. KE ENG SE SE KA BAKAANG KOTSI MO MMAINENG / MORAFONG? Dikotsi ha ngata dia etsahala/di ka etsahala ha bonolo: Khetha ENNGWE mo ho tse DINGWE LE TSE DINGWE TSE PEDI!

13.	☐ Ha metjene e sisinyeha thatha hore e sitwe ho laoleha.	☐ Ha mosebetsi o etsoa ntle ha ho latela mekhoa ea ho sebetsa e e sireletsehileng.
14.	☐ Ha basebetsi ba se na le ditlabakelo kampa disebedisoa tsa mosebetsi.	☐ Ha batho ba sa latele melao, mananeo ao a sireletsehileng kampa ba tsaea litsela tse kgusoane.
15.	☐ Ha baokameli ba sa jwetse basebetsi seo ba swanelang ho be ba se etsa kampa ba etse jaang.	☐ Ha o sa bone hantle; ka lebaka la lesufi kampa ho tletse lerule kampa mouwane.
16.	☐ Ha basebetsi e le ba batjha kampa ba se na boitemohelo.	☐ Ha tulo ya ho sebeletsa e tshesa haholo.
17.	☐ Ha ho sebetsa ka nnete, ka ho latela melao, ho sa khonehe kampa ho nka nako e telele, batho ba tsaea tsela tse kgusoane.	☐ Ha o sa bone hantle; ka lebaka la lesufi kampa ho tletse lerule kampa mouwane.
18.	☐ Ha batho ba sa latele melao, mananeo ao a sireletsehileng kampa ba tsaea litsela tse kgusoane.	☐ Ha basebetsi ba sa utlwisisi ditaelo tsa baokameli
19.	☐ Ha tulo ya ho sebeletsa e tshesa haholo.	☐ Ha basebetsi ba noele bojaala kampa ba tsubile lebaki.
20.	☐ Ha sedirisioa se dirisoa bohlasoa.	☐ Ha batho ba sa latele melao, mananeo ao a sireletsehileng kampa ba tsaea litsela tse kgusoane.
21.	☐ Ha o sa bone hantle; ka lebaka la lesufi kampa ho tletse lerule kampa mouwane.	☐ Ha motjene o se na dithibela-kotsi kampa di na le phoso.
22.	☐ Ha o sa bone hantle; ka lebaka la lesufi kampa ho tletse lerule kampa mouwane.	☐ Ha baokameli ba sa lebelle ho bona ha mosebetsi o etswa ho ya ka mo molaong.
23.	☐ Ha tulo ya ho sebeletsa e le e nnyenyane.	☐ Ha basebetsi ba se na thupello ea maleba mo mosebetsing o ba o etsang.
24.	☐ Ha di khemikhale tse kotsi kampa disebedisoa tse kotsi di sebedisoa.	☐ Ha metjene e sisinyeha thatha hore e sitwe ho laoleha.

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EMPLOYEE PERCEPTION SURVEY

A. BACKGROUND INFORMATION

Fana ka tsedimosetso e e latelago:

1. Na lefapha la gago la tiro ke lefe, tiro ya gago ke efe / maemo a gago mo tirong ke afe?

____

2. Naa o dira fa **KAE** ka mehla?

☐ Surface ☐ Haulage or X-Cut

☐ Development end ☐ Tips or Station

☐ Stope ☐ Underground Workshop

Fa o sa dire go lengwe la mafelo a a umakilweng, HLATHOLLA GORE KE FA KAE:

____

3. O simolotse **NENG** go dira kowo? ______________

4. Ke **DITIRO DINGWE DIFE** tse o didirileng **MO MMAINENG?** ______________

____

5. **O DIRILE NGWAGA DI LE KAE MO MMAINENG?** ______________

6. Naa o ile wa <u>bona kogotsa wa amega kotsing ya fa gare ga mmaine</u>?

☐ EE ☐ NNYAYA

6a) Fa oile wa <u>bona kgotsa wa amega kotsing ya fa gare ga mmaine</u>, **KA ENG se o akanyang gore SE KA BO SE BAKILE GORE KOTSI e direge?**

____

____

6b) **NAA O ILE WA TSWA KOTSI?** ☐ EE ☐ NNYAYA

Fa karabo e le EE; **KGOBALO** ya gago e bile **EFE?**

____

B. DITAELO FA O ARABA DIPOTSO

Mo matlakaleng a mabedi go na le distatamente mabapi le seo se ka bakang kotsi, le dikarabo tseo di tla feleletsang distatamente tseo. Dikarabo di tsamaya **di le pedi, di le pedi.**

- Mo dikarabong dingwe le dingwe di le pedi, tlhopa e le nngwe ye o bonang e le botoka go kgaisa. Ga go karabo ye e fosagetseng, empa mo **dikarabong o swanetse go kgetha e le nngwe ye o naganang gore e siame.**

- Fa dikarabong, **ye e siameng ke eo go ya ka wena, e ka bakang kotsi.**

- Etsa gore o tlhophe karabo e le nngwe. **O se ke wa tlola dikarabo dingwe.**

- O se senye nako entsi o nagana. Matlakala a mabedi a a latelang ga a swanela go go tsaya lebaka le le lele go feta metsotso e le lesome.

C. <u>KE ENG SEO SE KA BAKANG KOTSI MO MMAINENG?</u>
<u>Dikotsi go le gontsi di a direga/di ka diragala bonolo:</u>
Thlopa <u>ELENNGWE</u> gotswa fa go <u>DINGWE LE DINGWE DI LE PEDI</u>!

1.	☐	Fa lefelo la go direla le le mogote thata.	☐	Fa baokamedi ba tlisa batho bao ba se nang kitso kgotsa ba se ba katisiwa, gore ba thuse ka tiro nngwe.
2.	☐	Fa badiri ba sa itsi sepe ka ga tiro e ba e dirago.	☐	Fa lefelo la go direla le le lennye.
3.	☐	Fa badiri ba sa utlwisise sentle lenane kgotsa melao e ba swanelang go e latela.	☐	Fa metjhene e sisinyega thatha gore e sitwe go laolega.
4.	☐	Fa sedirisiwa se sa hlokomelwe ka tshwanelo kgotsa se sa beakangwe ka nako e swanetseng.	☐	Fa lefelo la go direla le le mogote thata.
5.	☐	Fa baokamedi ba sa lebelle tiro le go sedimosetsa badiri.	☐	Fa go na le lesata le lentsi gore batho ba tsebe go utlwana kgotsa go utlwa medumo ya tshedimosetso.
6.	☐	Fa go na le lesata le lentsi gore batho ba tsebe go utlwana kgotsa go utlwa medumo ya tshedimosetso.	☐	Fa batho ba sa latele melao, manane a tshireletsego kgotsa ba kgaoletsa.
7.	☐	Fa badiri ba se na kgotsa ba sa dirisi ditshireletsi tse nepagetseng kgotsa ditlabakelo tsa go itshireletsa	☐	Fa o sa bone sentle ka lebaka la lefifi kgotsa go tletse lerole kgotsa moowane.
8.	☐	Fa lefelo la go direla le le lennye.	☐	Fa badiri ba se nnyana go phetha tiro.
9.	☐	Fa o sa bone sentle ka lebaka la lefifi kgotsa go tletse lerole kgotsa moowane.	☐	Fa badiri ba sa itsi sepe ka ga kotsi e e ka ba welago le go re ba ka phema kotsi jaang.
10.	☐	Fa go dira tiro ka nepo, o latela molao, go ka batla nako e le ntsi, le gona batho ba kgaoletsa.	☐	Fa lefelo la go direla le le mogote thata.
11.	☐	Fa lefelo la go direla le le mogote thata.	☐	Fa motjhene o na le bothata kgotsa o sa dire sentle.
12.	☐	Fa go na le lesata le lentsi gore batho ba tsebe go utlwana kgotsa go utlwa medumo ya tshedimosetso.	☐	Fa badiri ba lwala kgotsa ba sa etekanela sentle.

C. KE ENG SEO SE KA BAKANG KOTSI MO MMAINENG?

Dikotsi go le gontsi di a direga/di ka diragala bonolo:

Thlopa ELENNGWE gotswa fa go DINGWE LE DINGWE DI LE PEDI!

13.	☐ Fa metjhene e sisinyega thatha gore e sitwe go laolega.	☐ Fa tiro e dirwa ntle ga go latela mekgwa ya go dira ka tshireletsego.
14.	☐ Fa badiri ba se na ditlabakelo kgotsa didirisiwa tsa tiro.	☐ Fa go na le lesata le lentsi gore batho ba tsebe go utlwana kgotsa go utlwa medumo ya tshedimosetso.
15.	☐ Fa baokamedi ba sa bolelle badiri se ba swanetseng go be ba sedira kgotsa ba dire jaang.	☐ Fa o sa bone sentle ka lebaka la lefifi kgotsa go tletse lerole kgotsa moowane.
16.	☐ Fa badiri e le ba bantshwa kgotsa ba se na maikatlapelo.	☐ Fa lefelo la go direla le le mogote thata.
17.	☐ Fa go dira ka nepo, o latela molao, go sa kgonagale kgotsa go tsaya lebaka le le lentsi, batho ba tsaya ditsela tse khutswane.	☐ Fa o sa bone sentle ka lebaka la lefifi kgotsa go tletse lerole kgotsa moowane.
18.	☐ Fa go na le lesata le lentsi gore batho ba tsebe go utlwana kgotsa go utlwa medumo ya tshedimosetso.	☐ Fa badiri ba sa utlwisisi ditaelo tsa baokamedi.
19.	☐ Fa lefelo la go direla le le mogote thata.	☐ Fa badiri ba nwele bojwala kgotsa ba tsubile motekwane.
20.	☐ Fa sedirisiwa se sebedisiwa boatla kgotsa ka mokgwa o fosagetseng.	☐ Fa go na le lesata le lentsi gore batho ba tsebe go utlwana kgotsa go utlwa medumo ya tshedimosetso.
21.	☐ Fa o sa bone sentle ka lebaka la lefifi kgotsa go tletse lerole kgotsa moowane.	☐ Fa motjhene o se na disireletsa-kotsi, kgotsa di sireletsa-kotsi di na le phoso.
22.	☐ Fa o sa bone sentle ka lebaka la lefifi kgotsa go tletse lerole kgotsa moowane.	☐ Fa baokamedi ba sa lebelle go bona fa tiro e dirwa go ya ka fa molaong.
23.	☐ Fa lefelo la go direla le le lennye.	☐ Fa badiri ba se na katiso ya nepo, kgotsa dikatiso-kgakollo mo tirong ye ba e dirang.
24.	☐ Fa di khemikhale tse kotsi kgotsa didirisiwa tse kotsi di dirisiwa.	☐ Fa metjhene e sisinyega thatha gore e sitwe go laolega.

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EMPLOYEE PERCEPTION SURVEY

A. INGXELO JIKEKELELE

Nceda unike ingxelo ecelwayo ngasezantsi:

1. Wenza msebenzi mni **NGOKU?** ____________________

2. **YEYIPHI INDAWO** odla ngokusebenza kuyo?

   ☐ Ngaphezulu ☐ Haulage or X-Cut

   ☐ Development end ☐ Etiphini okanye esititshini

   ☐ Esayidini ☐ Esitolo sokusebenzela sasemgodini

   Xa ingekho indawo osebenza kuyo kwezindayo zingasentla,

   YITSHO UKUBA YINDAWONI: ____________________

3. Wawuqala **NGOWUPHI UNYAKA** umsebenzi owenzayo ngoku? ____________________

4. Yeyiphi **EMINYE IMISEBENZI** oyenzileyo ezimayini? ____________________

   ____

5. **MINGAPHI IMINYAKA OYISEBENZILEYO EZIMAYINI?** ____________________

6. Uke wangqina okanye wabandakanyeka engozini yasemgodini?

   ☐ EWE ☐ HAYI

   6a) Xa wake wangqina okanye wabandakanyeka engozini yasemgodini, **YINTONI ocinga ukuba yaba NGUNOBANGELA WENGOZI** ukuba yenzeke?

   ____

   ____

   6b) Xa wake wabandakanyeka engozini yasemgodini, **WALIMALA?**

   ☐ EWE ☐ HAYI

   Ukuba **WALIMALA ,YINTONI INGOZI** owalimala yiyo?

   ____

B. IMIYALELO YOKUPHENDULA LEMIBUZO

Kulamakhasi mabini alandelayo kukhona ingxelo emalunga nokuba yintoni enokubangela ingozi, neempendulo ezingaba zizoukugcwalisa ingxelo. Iimpendulo zingambini, mbini.

- Kwimpendulo ezimbini khetha ocinga ukuba yeyona ebhetele. Akukho mpendulo inganyanisekanga , kodwa kwezimpendulo zimbini khetha le ocinga ukuba ibhetele kunenye.

- Kwiimpendulo ezingambini eyona ichanekileyo impendulo yeyona ibonakala ingaba ngoyena nobangela wengozi.

- Qiniseka ukuba kwiimpendulo ezingambini kukho enye oyikhethileyo. Ungatsibi nanye impendulo.

- Ungachithi ixesha elininzi ucingana nempendulo. Amakhasi amabini alandelayo angathatha kangangemizuzu elishumi ukuba uwagqibe.

C. **<u>YINTONI ENGENZA UKUBA KWENZEKE INGOZI EMGODINI</u>?**
Iingozi kuvamile ukuba zenzeke OKANYE zinokwenzeka lula:
KHETHA IMPENDULO <u>IBENYE KWEZIMPENDULO ZINGAMBINI</u>!

1.	☐ Xa indawo yokusebenza ishushu gqitha.	☐ Xa abaphathi beqasha okanye befaka abantu abangenamava okanye abangaqeqeshwanga ukuba benze umsebenzi okanye bancedise kulo msebenzi.
2.	☐ Xa abasebenzi bengazi umsebenzi abawenzayo.	☐ Xa kungekho ndawo yoneleyo yokusebenzela.
3.	☐ Xa abasebenzi bengayiqondi eyonandlela efanelekileyo okanye imigaqo ekufanele basebenze ngayo.	☐ Xa imatshini ishukuma (ingcangcazela) gqitha isenza ukuba kubenzima ukuyilawula.
4.	☐ Xa impahla yokusebenza ingalungiswa kahuhle okanye ingalungiswa xa kufanelekile.	☐ Xa indawo yokusebenza ishushu gqitha.
5.	☐ Xa abaphathi bengawujongi umsebenzi indlela omawuhambe ngayo futhi bengayaleli okanye bangabacebisi abasebenzi.	☐ Xa kukhona ingxolo eninzi eyenza ukuba abantu bangakwazi ukunxibelelana okanye bangayiva into ezokwenza ingozi.
6.	☐ Xa kukhona ingxolo eninzi eyenza ukuba abantu bangakwazi ukunxibelelana okanye bangayiva into ezokwenza ingozi.	☐ Xa abasebenzi bengafuni ukusebenza ngokwemigaqo yokubebenza neendlela ezikhuselekileyo okanye bethatha iindlela ezimfushane ukwenza umsebenzi.
7.	☐ Xa abasenzi bengenazo okanye bengazisebenzisi iimpahla ezifanelekileyo zokukhusela okanye zokuvikela ingozi.	☐ Xa kunzima ukubona, kuba kumnyama kakhulu okanye kukhona uthuli oluninzi okanye kuwe itafile.
8.	☐ Xa kungekho ndawo yoneleyo yokusebenzela.	☐ Xa abasebenzi aboneleyo bokwenza umsebenzi bengekho.
9.	☐ Xa kunzima ukubona, kuba kumnyama kakhulu okanye kukhona uthuli oluninzi okanye kuwe itafile.	☐ Xa abasebenzi bengazi ukuthi bangavikela kanjani ingozi.
10.	☐ Xa ukwenza umsebenzi ngokwemigaqo yomthetho kuzofuna ixesha elininzi futhi abantu bathatha iindlela ezimfutshane ukwenza umsebenzi.	☐ Xa indawo yokusebenza ishushu gqitha.
11.	☐ Xa indawo yokusebenza ishushu gqitha.	☐ Xa imatshini inika ingxaki okanye ingasebenzi kakuhle.
12.	☐ Xa kukhona ingxolo eninzi eyenza ukuba abantu bangakwazi ukunxibelelana okanye bangayiva into ezokwenza ingozi.	☐ Xa abasebenzi begula okanye bengakulungelanga ukusebenza okanye bediniwe.

C. <u>YINTONI ENGENZA UKUBA KWENZEKE INGOZI EMGODINI</u>?
Ilngozi kuvamile ukuba zenzeke OKANYE zinokwenzeka lula:
KHETHA IMPENDULO <u>IBENYE KWEZIMPENDULO ZINGAMBINI</u>!

13.	☐	Xa imatshini ishukuma (ingcangcazela) gqitha isenza ukuba kubenzima ukuyilawula.	☐	Xa umsebenzi wenziwe kungasetyenziswanga ezonandlela zikhuselekileyo zokusebenza.
14.	☐	Xa abasebenzi bengenazo izixhobo ezifanelekileyo zokwenza umsebenzi.	☐	Xa kukhona ingxolo eninzi eyenza ukuba abantu bangakwazi ukunxibelelana okanye bangayiva into ezokwenza ingczi.
15.	☐	Xa abaphathi bengabaxelelanga abasebenzi into ekufanele bayenze, okanye bayenze kanjani.	☐	Xa kunzima ukubona, kuba kumnyama kakhulu okanye kukhona uthuli oluninzi okanye kuwe itafile.
16.	☐	Xa abasebenzi bebatsha emsebenzini okanye bengenalo ixesha elide besebenza (bengenamava ngomsebenzi lowo).	☐	Xa indawo yokusebenza ishushu gqitha.
17.	☐	Xa ukusebenza ngokwemigaqo yokumthetho kungenzeki okanye kuthatha ixesha elininzi futhi abasebenzi bathatha indlela ezimfutshane ukwenza umsebenzi.	☐	Xa kunzima ukubona, kuba kumnyama kakhulu okanye kukhona uthuli oluninzi okanye kuwe itafile.
18.	☐	Xa kukhona ingxolo eninzi eyenza ukuba abantu bangakwazi ukunxibelelana okanye bangayiva into ezokwenza ingozi.	☐	Xa abasebenzi bengayiqundi imiyalelo yabaphathi.
19.	☐	Xa indawo yokusebenza ishushu gqitha.	☐	Xa abasebenzi bebesela utywala okanye betshaya intsangu.
20.	☐	Xa impahla yokusebenza isetyenziswe ngendlela engeyiyo okanye ngendlela engakhuselekanga.	☐	Xa kukhona ingxolo eninzi eyenza ukuba abantu bangakwazi ukunxibelelana okanye bangayiva into ezokwenza ingozi.
21.	☐	Xa kunzima ukubona, kuba kumnyama kakhulu okanye kukhona uthuli oluninzi okanye kuwe itafile.	☐	Xa imatshini ingenazo izikhuseli zokukhusela ingozi okanye ezozikhuseli zophukile.
22.	☐	Xa kunzima ukubona, kuba kumnyama kakhulu okanye kukhona uthuli oluninzi okanye kuwe itafile.	☐	Xa abaphathi bengawujongi ukuba umsebenzi wenziwa ngokomthetho.
23.	☐	Xa kungekho ndawo yoneleyo yokusebenzela.	☐	Xa abasebenzi bengazange bafumane uqeqesho olululo okanye uqeqesho lokuvuselela ukwenza umsebenzi abawenzayo.
24.	☐	Xa iikhemikhali ezinobungozi okanye iimpahla ezinobungozi zisetyenziswa.	☐	Xa imatshini ishukuma (ingcangcazela) gqitha isenza ukuba kubenzima ukuyilawula.

CSIR DIVISION OF MINING TECHNOLOGY
SIMRAC GAP 203:

"Possible Role of Environmental Factors in Causing or Contributing to Underground Accidents in Gold and Platinum Mining"

EMPLOYEE PERCEPTION SURVEY

A. <u>BACKGROUND INFORMATION</u>

Ucelwa ukuthi uphane ngolwazi o lulandelayo:

1. Ubumo bakho emsebenzini / Umsebenzi wakho / Ne ndawo yakho emsebenzini ngiyiphi?

   ____

2. Usesebenzela **KUPHI** ngokuvamile?

   ☐ Surface ☐ Haulage or X-Cut

   ☐ Development end ☐ Tips or Station

   ☐ Stope ☐ Underground Workshop

   Uma kingasi ngenye ye zindawo eziphezulu, ISHO UKUTHI KUKUPHI:

   ____

3. O cale **NGO NYAKA MUPHI** uku senenza umsebenzi lo? ________________

4. Yi **MISEBENZI MIPHI E MINYE** o khe wa yi sebenza **E MGODINI?**____________

   ____

5. **U SEBENZE IMINYAKA E MINGAKI E MGODINI?**________________

6. Wakhe wa <u>bona noma wathinteka engozini yase mgodini</u>?

   ☐ YEBO ☐ XAA

   6a) Uma wakhe wa <u>bona noma wathinteka engozini yase mgodini</u>, **YINI o cabanga ukuthi kwa BANGELA UKUTHI INGOZI idaleke?**

   ____

   ____

   6b) **WA LIMALA YINI?** ☐ YEBO ☐ XAA

   Uma impendule yakho ingu YEBO, Wa **LIMALA INI?**

   ____

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B. IZINDLELA ZO KU PHENDULA IMIBUZO

La emaphepheni a mabili ku na mastatement mayelana na lokhu o ku nga dala ingozi, kanye ne zimpendulo e zi zaliselela la yo mastatement. Lezo zimpendulo zi hamba nga **zimbili.**

- La ezimpendulweni ezinye nezinye ezi mbili khetha leyo o bona ku ngathi incono ku nenye. A ku na mpendulo engalungile kepha u **fanele ukhethe leyo wena ucabanga ukuthi ilungile.**

- La ezimpendulweni, **elungile ngileyo ukuya ngawe, e nga dala ingozi.**

- Yenza ukuthi u khethe impendulo e yodwa. **Unga zubi izimpendulo e zinye.**

- Unga cithi isikhathi e sinde ucabanga. La amaphepha a mabili a landelayo a fanele ukuthi a nga kuthathi amaminiti a dlula eshumini.

C. YINI LOKHO O KUNGA DALA INGOZI EMGODINI?

Kaningi izingozi ziyenzeka/zingenzeka ka lula:

Khetha EYODWA KWEZINYE NEZINYE E ZIBILI!

1.	☐	Uma indawo yokusebenzela ishisa kakhulu.	☐	Uma abawungameli baletha abasebenzi abangena lwazi nomaabanga lolongiwe ukuthi bancede ngomsebenzi othileyo.
2.	☐	Uma abasebenzi bengazilutho ngomsebenzi ebawenzayo.	☐	Uma indawo yokusebenzela iyincani.
3.	☐	Uma abasebenzi banga zwisisi kahle, indlela noma imiyalo ebafanele bayilandele.	☐	Uma imishini isikinyeka kakhulu ukuze ingakwazi ukulauleka.
4.	☐	Uma isisebenziswa singa nakiwe ngemfanelo noma singahlolwi nge sikhathi esifaneleyo.	☐	Uma indawo yokusebenzela ishisa kakhulu.
5.	☐	Uma abawungameli benga hloli umsebenzi noku bonisana nabasebenzi.	☐	Uma kunomsindo omningi o vimbela ukuthi abantu bangezwani noma ukuzwa imisindo ecwayisayo.
6.	☐	Uma kunomsindo omningi o vimbela ukuthi abantu bangezwani noma ukuzwa imisindo ecwayisayo.	☐	Uma abantu benga landeli imiyalo, izindlela ezivikelekileyo noma bethatha izindlela ezifushane.
7.	☐	Uma abasebenzi bengana noma benga sebenzisi izivimbelangozi ezifaneleyo noma imfanelo zoku zivikela.	☐	Uma ungaboni kahle ngenxa yomnyama noma kunethuli eliningi noma kune nkungu.
8.	☐	Uma indawo yokusebenzela iyincani.	☐	Uma abasebenzi bangenele uku gxina umsebenzi.
9.	☐	Uma ungaboni kahle ngenxa yomnyama noma kunethuli eliningi noma kune nkungu.	☐	Uma abasebenzi bengazi lutho ngengozi enga behlelayo nokuthi banga yivimba kanjani.
10.	☐	Uma ukwenza umsebenzi ngo kulandela imiyalo kucitha isikhathi esiningi, noma abantu bethatha izindlela ezifushane.	☐	Uma indawo yokusebenzela ishisa kakhulu.
11.	☐	Uma indawo yokusebenzela ishisa kakhulu.	☐	Uma umshini unenkinga noma unga sebenzi kahle.
12.	☐	Uma kunomsindo omningi o vimbela ukuthi abantu bangezwani noma ukuzwa imisindo ecwayisayo.	☐	Uma abasesbenzi begula noma bekhathele.

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C. **<u>YINI LOKHO O KUNGA DALA INGOZI EMGODINI?</u>**
<u>Kaningi izingozi ziyenzeka/zingenzeka ka lula:</u>
Khetha <u>EYODWA KWEZINYE NEZINYE E ZIBILI</u>!

13.	☐	Uma imishini isikinyeka kakhulu ukuze ingakwazi ukulauleka	☐	Uma umsebenzi wenziwa ngaphandle ko ku landela izindlela zo ku sebenza e zilungileyo.
14.	☐	Uma a basebenzi be ngana mfanelo noma insebenziswa zo msebenzi.	☐	Uma kunomsindo omningi o vimbela ukuthi abantu bangezwani noma ukuzwa imisindo ecwayisayo.
15.	☐	Uma abawungameli benga layeli abasebenzi into ebafanele ba yenze nokuthi ba yenze kanjani.	☐	Uma ungaboni kahle ngenxa yomnyama noma kunethuli eliningi noma kune nkungu.
16.	☐	Uma abasebenzi be basha noma be nganalwazi.	☐	Uma indawo yokusebenzela ishisa kakhulu.
17.	☐	Uma u ku sebenza nge ndlela efaneleyo, u landela imiyalo, ku nga kgonakali noma ku citha isikhathi esinde, abantu ba thatha izindlela e zifushane.	☐	Uma ungaboni kahle ngenxa yomnyama noma kunethuli elíningi noma kune nkungu.
18.	☐	Uma kunomsindo omningi o vimbela ukuthi abantu bangezwani noma ukuzwa imisindo ecwayisayo.	☐	Uma abasebenzi benga zwisisi imiyalo yomwungameli wabo
19.	☐	Uma indawo yokusebenzela ishisa kakhulu.	☐	Uma abasebenzi bephuze ugologo noma be bheme insango.
20.	☐	Uma isisebenziswa si sebenziswa kabi noma ngendlela engeyona.	☐	Uma kunomsindo omningi o vimbela ukuthi abantu bangezwani noma ukuzwa imisindo ecwayisayo.
21.	☐	Uma ungaboni kahle ngenxa yomnyama noma kunethuli elíningi noma kune nkungu.	☐	Uma umshini unga na zivimbela-ingozi noma izivimbela-ingozi zi ne nkinga.
22.	☐	Uma ungaboni kahle ngenxa yomnyama noma kunethuli elíningi noma kune nkungu.	☐	Uma abawungameli benga beki ukuthi ba bone uma umsebenzi wenziwa ngendlela efaneleyo yo ku landela imiyalo.
23.	☐	Uma indawo yokusebenzela iyincani.	☐	Uma abasebenzi ba nga lolongiwe ngemfanelo.
24.	☐	Uma amakhemikhale a yi ngozi noma insebenziswa e zine ngozi zi sebenziswa.	☐	Uma imishini isikinyeka kakhulu ukuze ingakwazi ukulauleka.

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APPENDIX 3 ACCIDENT INVESTIGATION FORMS

MD1208

DEPARTMENT OF MINERAL AND ENERGY
FORM 10

REPORTABLE ACCIDENT IN TERMS OF REGULATIONS 25.1.1 (a), (b), (c), (d) AND (f) AND 25.6 (a), (b), (c), (d) AND (e).
MINERALS ACT, 1991 REGULATION 34.1

Complete the form for reportable accidents in terms of regulations 25.1 (a), (b), (c), (d) and (f) and 25.6 (a), (b), (c), (d) and (e) and attach forms MD 1209, MD 1210, MD 1211, MD 1212, MD 1213 and MD 1214 where applicable.

A. MUST BE COMPLETED BY MINE

MINE'S ACCIDENT NUMBER	
NAME OF MINE	
MAIN COMMODITY	
TECHNICAL MANAGER (owner)	
MINING OPERATIONS	(Mark applicable block) UG OC AS
MAXIMUM DEPTH BELOW	
TYPE OF ACCIDENT	
NUMBER OF PERSONS KILLED	
TOTALLY DISABLED	
REPORTABLY INJURED	
DATE OF ACCIDENT	/ /
TYPE OF ACCIDENT	:
PLACE	UG OC AS
CLASS OF PLACE	
NAME OF WORKING PLACE	
DEPTH BELOW SURFACE (m)	
SECTION	
CLASSIFICATION	

DESCRIPTION OF ACCIDENT:

RESPONSIBLE PERSON(S):

ID NUMBER	NAME	CERTIFICATE NUMBER	OCCUPATION

AVERAGE NUMBER OF PERSONS AT WORK DURING PREVIOUS MONTH: UNDERGROUND: SURFACE:

MINE MANAGER SIGNATURE: .... Date:

B. REGIONAL INFORMATION (Must be completed by Region)

REGIONAL ACCIDENT NO.	
CAUSE	
INQUIRY	
DATE INQUIRY COMPLETED	
CONTRAVENTION	
ACT/REGULATION	
RME NAME	THREE INITIAL CODE
DATE REPORTED	

RME SIGNATURE: .... Date: 1998-______ - ________

MD1212

DEPARTMENT OF MINERAL AND ENERGY
FORM 11

REPORTABLE ACCIDENT IN TERMS OF REGULATIONS 25.1.1 (a), (b), (c), (d) AND (f).
DETAILS OF DECEASED OR INJURED PERSON
MINERALS ACT, 1991 REGULATION 34.1

Complete a form for each person killed, permanently disabled or reportably injured and attach the form to form MD 1208.
Codes to be used on this form are specified in the Reportable Accidents Code Book.

REGIONAL ACCIDENT NO										

A. MUST BE COMPLETED BY MINE		
MINE'S ACCIDENT NUMBER		
MINE'S RAND MUTUAL ASSURANCE CLAIM		
NAME OF MINE		
DATE OF ACCIDENT		/ /
B. DETAILS OF PERSON		
SURNAME		
FIRST NAME		
ID/PASSPORT NO.		
COMPLETE AT LEAST ONE OF THESE	INDUSTRY NUMBER	
	PF NUMBER	
	COMPANY NUMBER	
DATE OF BIRTH		
AGE		
COUNTRY OF ORIGIN OR PROVINCE		
STATISTICAL CODE		
MALE/FEMALE		
PRESENT OCCUPATION		
EXPERIENCE		
ACTIVITY		
NATURE OF INJURY		
BODY PART INJURED		
REPORTABILITY		
DATE OF DEATH		/ /
ALLOCATED DAYS LOST		

RME SIGNATURE: .... Date: 1998- ______ - ______

____________________ MINE

SAFETY OFFICER'S INJURY INVESTIGATION REPORT

A. DETAILS OF INJURED

NAME:	________	COY. NO.:	________
OCCUPATION:	________	I.D. NO.:	________
SECTION:	________	W/PLACE:	________
SHAFT/AREA:	________	INJURY:	________
DATE:	____ TIME: ____	DAY OF WEEK:	________
GANGER/ARTISAN:	________	S/SUP/FOREMAN	________
M.O./ENGINEER:	________		

B. DESCRIPTION

____

____

____

C. IMMEDIATE CAUSE

____

____

____

____

D. BASIC CAUSE

____

____

____

E. RECOMMENDATIONS

____

____

____

____

NAME: ________________ SIGNATURE: ________________

______________________________MINE

SAFETY OFFICER'S INJURY INVESTIGATION REPORT

REGULATION 2.19.1 (f)

Shaft: ______________________

Coy. No. Of Injured: ____________________

Date of Acc: __________________________ Time: ____________________

First Date off Work: ____________________

Date of investigation: __________________

Working Place: _______________________ Injuries: __________________

____

____

RESPONSIBLE PERSONS:

Team Leader: ____

Safety Rep: ____

Miner/Artisan: ____

S/Boss / F. Man: ____

M/O / GES: ____

Sect Man / ENG: ____

DESCRIPTION OF ACCIDENT

____

____

____

____

____

APPARENT CAUSES & CONTRIBUTING FACTORS

____

____

____

____

____

____

____

____

RECOMMENDATIONS

____

____

____

____

____

____

____

____

____

____

____

SIGNATURE (S.O.) ______________________________

SIGNATURE (C.S.O) ______________________________

______________________ MINE

INJURY-INCIDENT INVESTIGATION AND ANALYSIS. L.C.1

1. TYPE OF INCIDENT

☐ INJURY/ILLNESS ☐ PROPERTY DAMAGE ☐ FIRE/EXPLOSION ☐ PRODUCTION LOSS

☐ ENVIRONMENTAL ☐ NEAR-MISS ☐ OTHER

2. ROUTE

a) The investigation must be completed by the Investigation panel within 3 working days of the Injury/Incident occurring (Refer to standard practice L.C.5.1)

b) The review of Basic Causes and Remedial action must be completed by the relevant H.O.D. andSnr. H.O.D. within 7 days of the Injury/Incident occurring.

c) The follow-up must be completed by the investigation Panel within 10 days of the Injury/Incident occurring and must be submitted to the Safety co-ordinator who will complete the Evaluation. Program Deficiencies and the "Final report L.C.5.4.3" for Serious/Major incidents.

d) The Complete Report will be submitted to the General Manager for his comments.

3. INVESTIGATION PANEL

Leader of Investigation Panel: Mr................................ other members 1. ....

2. .... 3. .... 4. ....

Date submitted for review ....

Date of follow-up on Remedial Action ....

Date submitted to Safety Co-ordinator ....

ONLY IN THE EVENT OF INJURY/ILLNESS TO/OF PERSON SUBMIT THE FOLLOWING: -

COY.NO: .... TEAM NO: .... Date of Injury/Incident ....

______________________________ Date: ______________

Signature of Investigation Panel Leader

4. DETAILS OF THE INJURED/INCIDENT

Name of Injured: ____________________ Working Place: ________________

Age of Injured: ____________________ Section/Dept.: ________________

I.D. No. of Injured: ________________ Time of incident: ______________

Occupation: ______________________ Weekday: ___________________

Body Part Injured: _________________ Activity: ____________________

Type of Unit Damaged: ______________ Nationality: _________________

Experience in present occupation: ________________________________

Depth below surface at which the incident occurred (Surf = OM) ______________

Nature of Injury/Illness/Other Loss: _______________________________

Witness Coy. No. 1: ____________________ 2. ____________________

5. DESCRIBE THE SEQUENCE OF EVENTS. (IF THE INCIDENT WAS CAUSED BY F.O.G., TRUCK AND TRAM OR EXPLOSIVES, THEN COMPLETE THE APPLICABLE CHECKLIST, (AVAILABLE FROM SAFETY DEPT.) AS WELL.)

____

____

____

____

6. PROPER SKETCH/PHOTOS (PLAN AND SECTIONS WITH DISTANCES)

INFORMATION CHECK SHEET

7. AGENCY INVOLVED: Specify in space provided the object or substance most closely associated with the injury/incident.

1. Machines (drills, fans, pumps etc.) ______
2. Hoisting apparatus (jacks etc.) ______
3. Conveyor (belt, mono winch etc.) ______
4. Vehicles (all types) ______
5. Electrical (motors etc.) ______
6. Hand tools (Hammers etc.) ______
7. Chemicals (explosives, gases etc.) ______
8. Working surfaces (floors, platforms etc.) ______
9. Environmental (dust, fall of ground etc.) ______
10. Agencies (any object or substance not classified) ______

______

8. TYPE OF CONTRACT

1. Striking against ______
2. Struck by ______
3. Caught in, on or between ______
4. Fall on same level ______
5. Fall to different level ______
6. Slip (not fall) ______
7. Exposed to temperature extremes ______
8. Foreign bodies in eye ______
9. Type of incident not classified ______

______

______

9. ADDITIONAL INFORMATION

Attach statements and or other reports e.g. Rock Mechanics, Planned Task Observation, Disciplinary and Ventilation Reports to the back of this document.

10. UNSAFE CONDITION: Specify the principal unsafe condition which led to or was responsible for the injury/incident. (To assist, see page 9.)

1. Improper guarding (unguarded etc.) ______
2. Defective equipment (broken, slippery etc.) ______
3. Hazardous arrangement (poor, glare etc.) ______
4. Illumination (poor, glare etc.) ______
5. Ventilation (dusty, gassy etc.) ______
6. Protective Equip. (defective shoes, goggles, gloves etc.) ______
7. No unsafe condition ______
8. Unsafe condition not classified ______

______

11. UNSAFE ACT: EXPLAIN THE PRINCIPAL UNSAFE ACT (TO ASSIST, SEE PAGE 9).

1. Operating without authority (failure to secure or warn) ______
2. Operating/working at unsafe speed (too fast, throwing material etc.) ______
3. Making safety devices inoperable (removing etc.) ______

   ______
4. Using unsafe equipment (hands instead of equipment) ______

   ______
5. Unsafe loading (placing, mixing etc.) ______
6. Unsafe position (bent back etc.) ______
7. Working on moving or dangerous equipment (cleaning etc.) ______

   ______
8. Distracting (horseplay etc.) ______
9. Failure to use P.P.E. (goggles etc.) ______
10. No unsafe act ______
11. Unsafe act not classified (explain) ______

    ______

12. **CAUSE ANALYSIS**
(SEE PAGE 9)

A. PERSONAL FACTORS: What did people do or fail to do that directly contributed to the incident? Be specific, for example: "Did not lock out power before making adjustment".

____

____

____

CHECK ITEMS BELOW WHICH CONTRIBUTED TO THE INCIDENT

□ Did not know of hazard □ Did not follow correct way □ Did not follow job standard □ Willful deviation from standard □ Low level of skill for job □ Was fatigued □ Not trained for job □ Tried to avoid effort needed □ Tried to avoid discomfort □ Failure to plan job □ Failure to follow plan or instructions □ Emotion upset □ Was ill, incapacitated □ Had poor vision or hearing □ Not using protective equipment □ Was physically/ mentally handicapped.

Describe ______________________________

____

B. JOB FACTORS: What inadequacies in design, maintenance or conditions in equipment, materials and the environment contributed to the incident? Be specific.

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CHECK ITEMS BELOW WHICH CONTRIBUTED TO THE INCIDENT

□ Worn out from normal use □ Abuse □ Basic design □ Improper assembly □ Tampering/unauthorised removal □ Congestion, lack of storage space □ Inadequate leadership/supervision □ Lack of order requirement □ Lack of order enforcement □ Adverse weather/natural environment □ Illumination □ Ventilation □ Deficient temperature control □ Exposure to vibration □ Deficient temperature control □ Exposure to vibration, stress □ Deficient pre-use inspection □ Deficient critical parts inspection □ Deficient general inspection □ others.

C. What inadequacies in programs, standards or compliance with standards are responsible for above contributing causes?

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____

13. ACTION PLAN (Remedial actions)
What has and/or should be done to control the causes listed

	WHO	WHEN	SIGN

14. IMMEDIATE SUPERVISOR'S COMMENTS

____

____

Sign: ____________________

SAFETY REP'S COMMENTS

____

____

Sign: ____________________

15. REVIEW (Reviewer's reactions to the investigator's analysis of the basic causes and the remedial actions directed. The possible inadequacies in the programme standards or compliance to standards.)

(i) SUB H.O.D. (e.g. M/O, Foreman, Superintendent)

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(ii) H.O.D. (e.g. Sect. Manager, Sect. Engineer, Plant Manager)

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Sign: ____________________

16. FOLLOW-UP ON REMEDIAL ACTION

	WHO	COMPLETED YES/NO	SIGN

What are the reasons for delays on Remedial Action, if any? ____________________

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17. EVALUATION (TO BE COMPLETED BY SAFETY DEPARTMENT).

(i) LOSS SEVERITY □ Minor □ Serious □ Major.

(ii) PROBABILITY OF RECURRENCE □ Frequent □ Occasional □ Seldom.

EVALUATION OF INVESTIGATION REPORT

EVALUATION FACTORS	POSSIBLE POINTS	POINTS AWARDED
1. Timelines of report - within 24 hours. Subtract 5 points for each additional day.	20	
2. Accuracy and completeness of identifying information.	10	
3. Evaluation of severity potential and probable recurrence rate.	5	
4. Clear step-by-step description of what happened.	15	
5. Analysis of basic and immediate causes.	15	
6. Adequacy of corrective actions to solve problems.	30	
7. Proper signatures.	5	
TOTAL SCORE	100	

18. <u>CONTROL FACTORS</u> N.B.! (TO BE COMPLETED BY SAFETY DEPARTMENT)

<u>Programme Elements</u>

		P	S	C
1	Leadership and Administration			
2	Management Training			
3	Planned Inspections			
4	Task Analysis and Procedures			
5	Injury/Incident Investigations			
6	Task Observation			
7	Emergency Preparedness			
8	Organizational Rules			
9	Injury/Incident Analysis			
10	Employee training			

LEGEND: Programme Element Implementation Need, S: Standard(s) Inadequate, C: Standard(s) compliance Inadequate

		P	S	C	
11	Personal Protective Equipment				
12	Health Control				
13	Programme Evaluation System				
14	Engineering Controls				
15	Personal Communications				
16	Group Meetings				
17	General Promotion				
18	Hiring and Placement				
19	Purchasing Control				
20	Off the Job Safety				

Estimated cost: ______________________ Actual cost: ________________

GENERAL MANAGER'S/SENIOR H.O.D. COMMENTS: ____________________

____

______________________________________SIGN: ____________________

IMMEDIATE CAUSES: CHECK ALL APPLICABLE SUB-STANDARD ACTIONS

1. Operating equipment without authority.
2. Failure to warn.
3. Failure to secure.
4. Operating at improper speed.
5. Making safety devices inoperable.
6. Removing safety devices.
7. Using defective equipment.
8. Using equipment improperly.
9. Failing to use personal protective equipment properly.
10. Improper loading.
11. Improper placement.
12. Improper lifting.
13. Improper position for task.
14. Servicing equipment in operation.
15. Horseplay.
16. Under influence of alcohol and/or other drugs.

SUB-STANDARD CONDITIONS

1. Inadequate guards or barriers.
2. Inadequate or improper protective equipment.
3. Defective tools, equipment and materials.
4. Congestion or restricted action.
5. Inadequate warning system.
6. Fire and explosion hazards.
7. Poor housekeeping; disorder.
8. Hazardous environmental conditions: gases, dusts, smoke, fumes, vapours.
9. Noise exposures.
10. Radiation exposures.
11. High or low temperature exposures.
12. Inadequate or excess exposures.
13. Inadequate ventilation.

BASIC CAUSES OF LOSS: PERSONAL FACTORS

- INADEQUATE PHYSICAL/PHYSIOLOGICAL CAPABILITY
  - Inappropriate height, weight, size, strength, reach, etc.
  - Restricted range of body movement.
  - Limited ability to sustain body positions.
  - Substance sensitivities or allergies.
  - Sensitivities to sensory extremes (temperature, sounds, etc.)
  - Vision deficiency.
  - Hearing deficiency.
  - Other sensory deficiency (touch, taste, smell, balance).
  - Temporary disabilities.
- INADEQUATE MENTAL/PSYCHOLOGICAL CAPABILITY
  - Fears and phobias.
  - Emotional disturbance.
  - Intelligence level.
  - Inability to comprehend.
  - Poor judgement.
  - Poor co-ordination.
  - Slow reaction time.
  - Low mechanical aptitude.
  - Low learning aptitude.
  - Memory failure.
- PHYSICAL OR PHYSIOLOGICAL STRESS
  - Injury or illness.
  - Fatigue due to task load or duration.
  - Fatigue due to lack of rest.
  - Fatigue due to sensory overload.
  - Exposure to health hazards.
  - Exposure to temperature extremes.
  - Oxygen deficiency.
  - Atmospheric pressure variation.
  - Constrained movement.
  - Blood sugar insufficiency.
  - Drugs.
- LACK OF KNOWLEDGE
  - Lack of experience.
  - Inadequate orientation.
  - Inadequate initial training.
  - Inadequate update training.
  - Misunderstood directions.
- LACK OF SKILL
  - Inadequate initial instruction.
  - Inadequate practice.
  - Infrequent performance.
  - Lack of coaching.
- IMPROPER MOTIVATION
  - Improper performance is rewarding.
  - Proper performance is punishing.
  - Lack of incentives.
  - Excessive frustration.
  - Inappropriate aggression.
  - Improper attempt to save time or effort.
  - Improper attempt to avoid discomfort.
  - Improper attempt to gain attention.
  - Inappropriate peer pressure.
  - Improper supervisory example.
  - Inadequate reinforcement of proper behaviour.
  - Improper production incentives.
- MENTAL OR PSYCHOLOGICAL STRESS
  - Emotional overload.
  - Fatigue due to mental task load or speed.
  - Extreme judgement/decision demands.
  - Routine, monotony, demand for uneventful vigilance.
  - Extreme concentration/perception demands.
  - "Meaningless" or "degrading" activities.
  - Confusing directions.
  - Conflicting demands.
  - Preoccupation with problems.
  - Frustration.
  - Mental illness

JOB FACTORS

- INADEQUATE LEADERSHIP AND/OR SUPERVISION
  - Unclear or conflicting reporting relationships.
  - Unclear or conflicting assignment of responsibility.
  - Improper or insufficient delegation.
  - Giving inadequate policy, procedure, practice or guidelines.
  - Giving objectives, goals or standards that conflict.
  - Inadequate work planning or programming.
  - Inadequate instructions, orientation and/or training.
  - Providing inadequate reference documents, directives and guidance publications.
  - Inadequate identification and evaluation of loss exposures.
  - Lack of supervisory/management job knowledge.
  - Inadequate matching of individual qualifications and job/task requirements.
  - Inadequate performance measurement and evaluation.
  - Inadequate or incorrect performance feedback.
- INADEQUATE ENGINEERING
  - Inadequate assessment of loss exposure.
  - Inadequate consideration of human factors/ergonomics.
  - Inadequate standards, specifications and/or design criteria.
  - Inadequate monitoring of construction.
  - Inadequate assessment of operational readiness.
  - Inadequate monitoring of initial operation.
  - Inadequate evaluation of changes.
- INADEQUATE PURCHASING
  - Inadequate specifications or requisitions.
  - Inadequate research on materials/equipment.
  - Inadequate specification to vendors.
  - Inadequate mode or route of shipment.
  - Inadequate receiving inspection and acceptance.
  - Inadequate communication of safety and health data.
  - Improper handling of materials
  - Improper storage of materials
  - Improper transporting of materials.
  - Improper identification of hazardous items.
  - Improper salvage and/or waste disposal.
- INADEQUATE MAINTENANCE
  - Inadequate preventive
    - assessment of needs.
    - scheduling of work.
    - examination of units.
    - cleaning or resurfacing.
  - Inadequate reparative
    - communication of needs.
    - scheduling of work.
    - examination of units.
    - part substitution.
- INADEQUATE TOOLS AND EQUIPMENT
  - Inadequate assessment of needs and risks.
  - Inadequate human factors/ergonomics consideration.
  - Inadequate standards or specifications.
  - Inadequate availability.
  - Inadequate adjustment/repair/maintenance.
  - Inadequate salvage and reclamation.
  - Inadequate removal and replacement of unsuitable items.
- INADEQUATE WORK STANDARDS
  - Inadequate development of standards
    - inventory and evaluation of exposures and needs.
    - co-ordination with process design.
    - employee involvement.
    - inconsistent standards/procedures/rules.
  - Inadequate communication of standards
    - publication.
    - distribution.
    - translation to appropriate languages.
    - reinforcing with signs, colour codes and job aids.
  - Inadequate maintenance of standards
    - tracking of work flow.
    - updating.
    - monitoring use of standards/procedures/rules.
- WEAR AND TEAR
  - Inadequate planning of use.
  - Improper extension of service life.
  - Inadequate inspection and/or monitoring.
  - Improper loading or rate of use.
  - Inadequate maintenance.
  - Use by unqualified or untrained people.
  - Use for wrong purpose.
- ABUSE OR MISUSE
  - Condoned by supervision
    - intentional.
    - unintentional.
  - Not condoned by supervision
    - intentional.
    - unintentional.