Safety in Mines Research Advisory Committee

Investigation into the causes of accidents on scraper systems in the Gold and Platinum mining sectors

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Executive Summary

Scraper winch cleaning is well known and widely used in the South African gold and platinum mines to clean the rock from underground stopes and gullies after the blast. However, there are risks and hazards associated with the design, installation and cleaning operations of the scraper winch systems that require identification.

This research report identifies the risk and hazards associated with scraper winch systems that may lead to potential accidents in the gold and platinum sector. The research also suggest whether scraper winch systems are a major safety risk, and if the associated risk is a managerial and an operational issue, or whether further research is required to provide potential solutions to the identified risk.

The initial stage of the research concentrated on an analysis of the SAMRASS database. The analysis indicated that accidents associated with scraper winch systems in the gold sector accounted for 5%, and in the platinum sector for 9%, of all underground mine related accidents. The analysis also indicated an increase in the fatality rates for the platinum sector with a decrease in injury rate for both gold and platinum sector between the periods of 1988 to 2002. The indications therefore were that scraper winch systems do indeed constitute a safety risk in the gold and platinum mining industry.

A risk profile study was conducted to assess the nature and extend of the identified accidents associated with scraper winch systems. The results of the risk profile are given in the table below. It can be seen that significant hazards in the gold sector are due to the scraper/scoop (33%), whilst scraper winch rope accidents are significant for both the platinum (31%) and the gold (30%) sector.

Risk Profile of the accidents associated with scraper winch systems.

Hazards	Platinum (%)	Gold (%)
Rope	31	30
Snatch block	23	16
Winch	24	13
Scraper/Scoop	21	33
Other	1	8

To complement the risk profile, an activity analysis based on the SAMRASS data of the hazards associated with scraper winch systems was conducted. The results are provided below:

- ✍ ***Rope related accidents:*** Rope striking workers is significant for both gold (25%) and platinum (23%) sector.
- ✍ ***Snatch block related accidents:*** Eyebolt/Snatch block coming out represents more than one-third of all the scraper winch related accidents for both gold and platinum. Winches being started without warning (26%) was significantly higher in platinum than in the gold sector.
- ✍ ***Winch related accidents:*** Drum/Rope entanglement is significantly high for both platinum (49%) and gold (40%) sector.
- ✍ ***Scoop related accidents:*** Workers being struck by the scoop is significantly high in platinum (37%).

An analysis of the activities of the workers during the time of the scraper winch accident profile was investigated. The investigation revealed that winch operators, stope workers, general miners, shift bosses and drillers are prone to scraper winch accidents. Shift bosses and miners might be involved in accidents during supervising of the crew due to fouling of the rope, incorrect positioning and while travelling in the stope. Most injuries occurred at the beginning of the morning shift when most workers are in groups of occupation and fatal accidents occurred mostly during night shifts when there was likely to have been absence of supervision and loss of concentration and awareness amongst workers. Principal causes of the scraper winch accidents in relation to the people activities (SAMRASS database) were identified as follows:

- Poor adherence of standards and procedures
- Lack of training and its practical application to the actual working environment
- Poor hazard identification skills and perception of risks
- Management and supervision of safe working practices and procedures.

To complement the SAMRASS database investigation, the research team also conducted underground visits and interviews with mine personnel associated with the management and operations of scraper winch systems to identify practices and causes of accidents from this perspective. The main finding of the underground observations was that ‘rigging’, ‘signalling devices’ and ‘winches being started without warning’ were identified as the main/significant hazards. During the underground investigations, it was found that the workers did not always adhere to mine standards and procedures. Further, there appeared to be a lack of training and practical application in the working environment. In general, underground workers are not aware enough about scraper winch hazard identification and perception of potential risks. Management and supervision of safe working practices and procedures was identified as being an area requiring definite further attention.

In overall terms, the underground findings were in agreement with the SAMRASS investigation.

In parallel with the practical investigations, a health and safety risk assessment analysis with respect to the design, installation and operation of scraper winch systems was conducted. The risk assessment confirmed hazards similar to the SAMRASS and underground investigations i.e. being struck by winch (during transportation, installation, operation or removal), ropes, scoops, snatchblock; punctured by rope strands; and entanglements. Importantly, the risk assessment identified significant shortcomings in scraper winch control measures, limitations in rules and standard procedures, lack of training, lack of routine inspections, and inadequate communication systems. The investigation also highlighted that Regulations on scraper winch systems need to be revised, a process that is already underway, and improved controls put in place. A document to give guidance on adequate controls and applications of best practice is also needed.

Overall, the research work indicates that scraper winch accidents are primarily a managerial and operational issue. A great deal of further effort is directed at changing peoples attitudes towards risk identification and hazard recognition, appropriate training, adherence to mine standards, as well as the management and supervision of scraper winch systems is required. Mining houses must continue to be diligent to ensure that standards are implemented and enforced. Furthermore, risk assessments need to be integrated with the mine standards.

The following are recommendations are made:

- Further research into “soft issues” is needed
- Review the starting-up procedures of scraper winch systems.
- Put in place effective warning devices i.e. better communication between workers and the winch operators.
- Review underground stoping layouts such that workers are separated from the scraper path.
- Improve upon standards e.g. winch installation and transportation
- Review rope splicing i.e. loop splicing versus roll splicing.
- Review of coiling mechanism of the winch system
- Improve winch operator ergonomics due to confined stoping environment.
- Ensure that behaviour based safety programmes are focussed not only on workers, but also on front-line supervisors and managers. The mining industry must take cognisance of the human factors that contribute to the potential for human failure.

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1 Introduction

Scraper winch systems are commonly used underground to clean broken rock from the stope face and gullies after the blast.
Although no estimate of the total number of scraper units in use in South Africa is available, the figure is believed to run into many thousands. It is further recognized that scrapers are an integral part of the narrow reef mining methods employed on gold and platinum mines, working in the face as well as in strike and dip gullies.
Scraper systems are accountable for a significant number of accidents underground.

This report investigates and highlights the causes of accidents on scraper winch systems in the gold and platinum sector, with an intention to determining whether further research is required to reduce and prevent accidents as far as possible in the future. In addition, the study is aimed at providing a guide to best practice in terms of the design, installation and operation of scraper winch systems.
The report also provides an analysis of the SAMRASS database for the period 1988 to 2002 where the indications are that accidents associated with scraper winches account for about 5% of all underground accidents in gold mines, and about 9% of all accidents in platinum mines.

The objectives of this research project are:

- To analyse records of accidents that are associated with scraper winch systems held on the SAMRASS database;
- To identify the significant potential hazards associated with scraper winch operations;
- To identify the typical control measures that are used on scraper winch systems and any associated shortcomings that may lead to accidents, i.e. a risk assessment based identification of critical areas associated with current equipment design, installation and operation.
- To make recommendations (operational or research related) to improve the safety of scraper winch operations

The study intends to determine whether scraper winch systems are indeed a major risk to the gold and platinum sector and to identify if further specific research in various aspects of scraper winch systems is required.

The work was done with due regard to a legal framework covering health and safety in South African mines.

2 Research methodology

The research methodology employed by the research team was as follows:

2.1 Literature review

A literature review was conducted to investigate both South African and international (USA, UK and Canada) experiences on scraper systems. All the literature found focused primarily on operational issues and excluded specific safety related issues.

As part of this review, a study of the legal framework in South Africa was also undertaken to identify which Regulations (if any) applied to scraper winch systems. At the present time there are two principal items of legislation that apply to mining activities, which are:

- the Mine Health and Safety Act (MHSA) of 1996 and Regulations; and
- the Minerals Act of 1991 and Regulations.

The MHSA was promulgated in January 1997 and it is intended that its Regulations will replace those of the Minerals Act, but drafting of these Regulations is still in progress. As a result, the legal requirements that are applicable to scraper winch systems are still covered by the Minerals Act and its Regulations, and Appendix 6 contains a detailed review of these requirements.

A literature review was conducted to investigate international experiences on scraper systems in conjunction with the South African situation. The literature search was done through libraries, available printed media and internet resources.

2.2 Analysis of SAMRASS database

Data from the SAMRASS database between the periods of 1988 to 2002 was analysed to identify the fatality and injury trends within the gold and platinum sector, and the hazards and causes of scraper winch related accidents. The results of this analysis are presented in Section 4.

2.3 Mine and supplier interviews

Visits were made to a number of gold and platinum mines, and also to suppliers of winches and associated scraper equipment. Findings from the SAMRASS database were used to prepare a generic questionnaire that was used during these visits. A summary of these questions is given in Appendix 1

2.4 Risk Assessment

The research team used the information obtained from the SAMRASS database, as well as their observations during the mine and supplier visits, to undertake a comprehensive risk assessment of scraper winch operations. This risk assessment identified the significant potential hazards associated with scraper winch operations, as well as typical control measures used by mines, and their associated shortcomings. The identification of such shortcomings is important as it is the failure of these control measures that causes accidents. An outline of the risk assessment process used in the study is given in Appendix 2. The full Risk Assessment is given in Appendix 4, and the results are discussed in Section 5.

2.5 Human Failure Potential Assessment

Past SIMRAC research studies by Simpson *et al.* (1996) and Rushworth *et al.* (1999) have consistently shown that human failures are major contributors to transportation and tramming accidents in mines. A human failure potential assessment was also undertaken at the same time as the risk assessment in order to assess the influence of human factors on the reliability and efficiency of control measures designed to reduce risks related to scraper winch systems.

The approach followed was to examine potential human failure associated with the following factors:

- the job factors such as tasks, procedures, and the environment;
- the individual factors such as competence, skills, attitudes, and risk perceptions; and
- the organisation and management factors such as leadership, communication, and culture.

Appendix 5 contains an overview of the Assessment of Human Failure Potential.

3 Literature review

The literature search (USA, Britain and Canada) revealed that the international publications primarily focused on operational issues and excluded safety related issues. The South African literature search found similar results. After consulting a SIMRAC committee member about the unavailable literature on the safety related issues of scraper systems, it was agreed that further work on the literature search be limited and that more effort be expended on the remaining tasks.

4 Scraper Winch Accident Statistics

Accidents associated with scraper winch systems are classified under ‘transportation’ accidents on the SAMRASS database. Analysis of the SAMRASS database for the period 1988 to 2002 indicates that transportation accounts for 22% of all accidents in underground gold mines and 25% of all accidents in platinum mines.

According to the SAMRASS database, transportation is divided in to the following areas:

1. Conveyor belts
2. Locomotives
3. Scrapers
4. Trackless mobiles
5. Conveyances

Accidents associated with scrapers account for 23% of all transportation accidents within gold mines, and 36% of all transportation accidents within platinum mines.

4.1 Initial Analysis

The initial analysis of accident records between the periods 1988 to 2002 revealed the following:

- The rate of fatalities per 1000 employees per year, as shown in Figure 4-1 has levelled off in gold mines and is showing signs of decreasing to levels below the current average rate of 0,025 fatalities per 1000 employees per year. This, however, is still above the long term SIMRAC target fatality rate for gold mines i.e. 0,02 fatalities per 1000 employees per year.

  The average injury rate in gold mines between 1988 and 1998 was 1,00 injuries per 1000 employees per year, and has since then decreased to 0,40 injuries per 1000 employees per year in 2002, well below the long term SIMRAC target of 1,00 injuries per 1000 employees per year for gold mines (Figure 4-2).

- In platinum mines, the average rate of fatalities per 1000 employees increased from 0,03 before 1995, to well over 0,04 from 1996 to 2002 (Figure 4-1). There was an enormous increase in fatalities in 2002, with the fatality rate at 0,4 fatalities per 1000 employees. This is significantly above the 0,01 fatalities per 1000 employees per year, the long term SIMRAC target fatality rate for platinum mines.

  In platinum mines, the injury rate increased steadily from 1988 to 1996 when it reached a high level of 1,20 injuries per 1000 employees per year (Figure 4-2). The rate has since dropped to 0,60 injuries per 1000 employees per year, well below the long term SIMRAC target injury rate of 0,90 injuries per 1000 employees per year.

The above assessment indicates that platinum mines have been more prone to scraper winch accidents than the gold mines. The possible reasons for this could be:

- Production rate i.e. high face advance
- Mining layout i.e. long centre gully pull lengths
- Expansion of mines i.e. recruitment of inexperienced workforce.

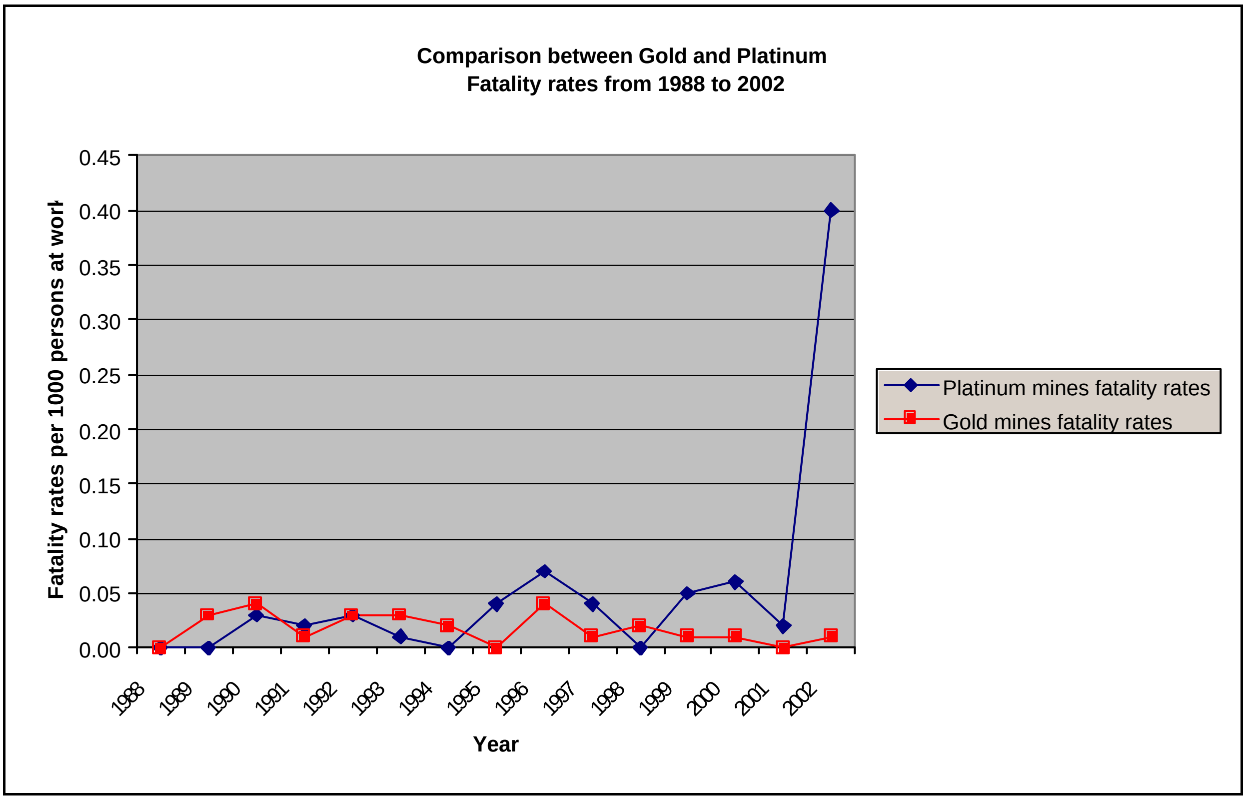

Figure 4-1: Gold and platinum mines fatality rates from 1988 to 2002

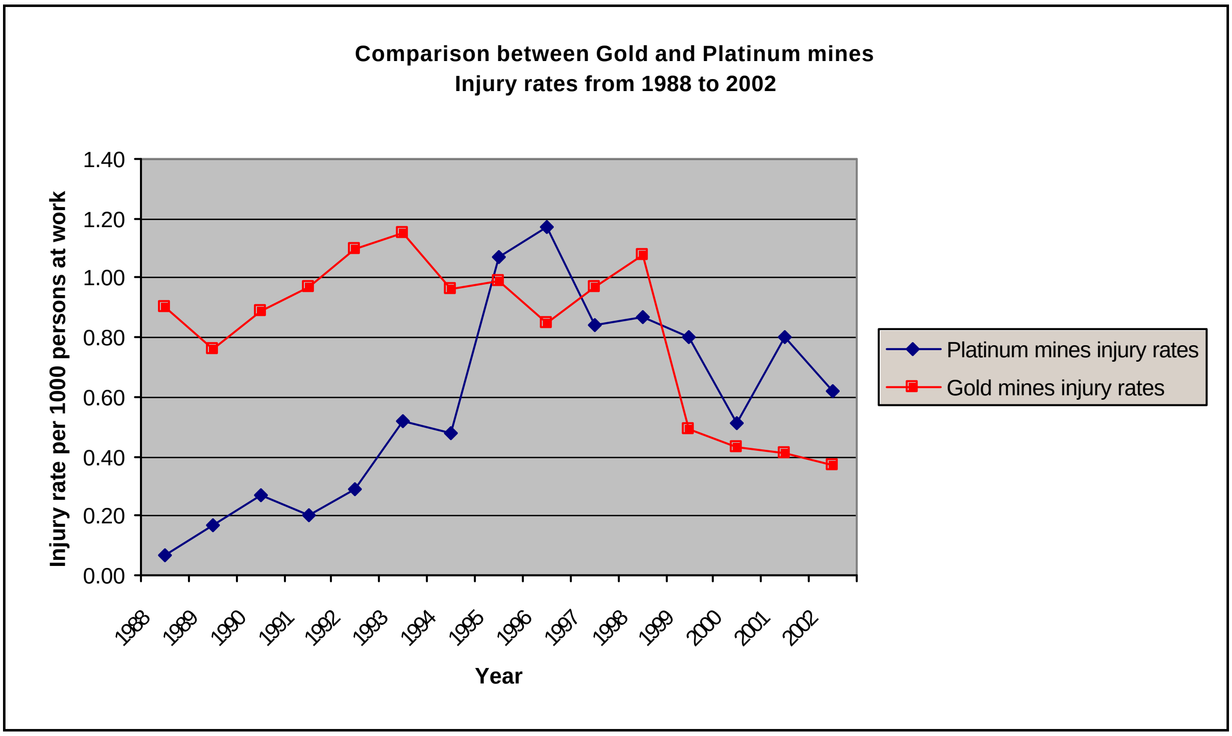

Figure 4-2: Gold and platinum mines injury rates from 1988 to 2002

4.2 Scraper hazard description

For the purpose of this evaluation, scraper winch accidents associated with the SAMRASS database were grouped under the following sub-headings:

- ***Rope:*** Accidents involving contact with the rope. For example, being struck by the rope whilst travelling, handling the rope, repairing the rope etc. The mines' choice of rope sizes and quality was a concern to the research team, and therefore a better understanding of the causes of the accidents was considered important.
- ***Snatch block:*** Accidents involving contact with the snatch block, particularly where the eye-bolt comes out during scraping operations.
- ***Winch:*** Accidents involving the winch, caused by poor coiling of the rope and other conditions leading to entanglement or breakage at the winch drum, as well as accidents brought about by poor ergonomics;
- ***Scraper / Scoop:*** Accidents that occur in the path of the scraper either on the face or in the gullies, such as operators being struck by the scoop while in

operation or transporting the scoop. Another area of concern is in the transportation of the scraper scoop, as workers are often injured while transporting the scoop.

Table 4-1 provides a breakdown of each accident type based on the above described systems grouping, expressed as a percentage of the total number of accidents associated with scraper winch systems as a whole..

A five-year period was selected for gold and platinum, i.e. from 1998 to 2002. The data was further scrutinised to establish the activity of the injured person at the time of the accident.

Table 4-1: Percentage hazard for platinum and gold

Hazards	Platinum (%)	Gold (%)
Rope	31	30
Snatch block	23	16
Winch	24	13
Scraper/Scoop	21	33
Other	1	8

The SAMRASS database highlighted the following areas of concern:

- Workers in the gold sector are prone to hazards caused by the scraper/scoop (33%).
- Significant hazards caused by scraper winch rope are significant for both gold (30%) and platinum (31%).

4.3 Activity of injured person

The data was also analysed in terms of the activities of those who were involved in accidents at the time they were injured and the occupation of the injured.

Table 4-2 below provides a summary:

Table 4-2: Activity of injured person in gold and platinum sector

Activity	Platinum (%)	Gold (%)
Rope related accidents		
Rope strikes worker	23	25
Repairing rope	9	6
Travelling	11	12
Winch started without warning	9	12
Breaking rope	12	10
Rope fouling	10	14
Support related accidents	5	2
Rock related accidents	5	4
Others	16	15
Snatch block related accidents		
Eyebolt out	34	39
Repairing snatch block	3	15
Winch started without warning	26	9
Struck by snatch block	-	16
Handling of rope	16	-
Fouling	7	2
Others	14	19
Winch related accidents		
Drum/Rope entanglement	49	40
Transporting/Handling rope	15	15
Handle and Clutch band	18	14
Others	18	31
Scoop related accidents		
Struck by scoop	37	16
Travelling	13	7
Winch started without warning	15	5
Handling	12	11
Rock related accidents	10	5
Support dislodged	7	9
Observing or supervising	-	12
Others	6	35

NB: Others are insignificantly grouped contributors to activities.
From the activity analysis, it is concluded that (Table 4-2):

- ***Rope related accidents:*** Being struck by the rope is significant for both gold (25%) and platinum (23%) sector. However, the overall cause is unknown.
- ***Snatch block related accidents:*** Eyebolt / Snatch block coming out represents more than one-third of all accidents. However, the winch being started without warning (26%) is significant in platinum compared to the gold sector.
- ***Winch related accidents:*** Drum / Rope entanglement is significantly high for both platinum (49%) and gold (40%) sector. The winch being started without warning (26%) is significant in platinum compared to the gold sector
- ***Scoop related accidents:*** Workers being struck by scoop (37%) is significantly high in platinum mining sector, but there is no clear explanation of the cause of accidents from the SAMRASS database.

The time of accidents was consolidated into four time zones as follows:

- ‘Night’ - Midnight to 06:00 am
- ‘Morning’ - 06:00 am to 12:00 pm
- ‘Afternoon’ - 12:00 pm to 06:00 pm
- ‘Evening - 06:00 pm to midnight

Table 4-3: Time of accident – Injury and fatality percentage (1998 to 2002)

	Percentage Injury	Percentage Fatality
Night	33.6	58.1
Morning	45.6	19.4
Afternoon	17.2	16.1
Evening	3.6	6.5

From Table 4-3 it is noted that most of the injuries occur during the morning shift (45,6 %), this is probably due to the fact that most of the workers are in the stope, transporting material or travelling to the stope face while the scraper winch is in operation. At the other extreme Table 4-3 also indicates that most workers are killed (58,1%) during the night shift. This may be due to the fact that there is less supervision on night shift and that night shift is primarily a cleaning shift.

The breakdown by activity given above was useful in identifying specific hazards and causes, and this information was utilised in the subsequent mine visits and risk assessment.

The breakdown confirmed the findings of risk assessment research regarding the identification of hazards. What was required was an understanding of occupational role of the injured person.

Table 4-4 shows an analysis of the occupation of the personnel involved in accidents. For the purpose of this research, the analysis was simplified through treating several occupations as a group from the SAMRASS database.

- ‘Driller’: hand percussion/jackhammer’ and ‘Drilling worker’ were put into one group called ‘Drillers’
- ‘Miners assistance’, ‘Stope team worker’ and ‘Team leader’ were grouped together as ‘Stope workers’

Table 4-4: Occupation of personnel involved in accidents

Occupation	Percentage of Total
Winch operator	43.9
Stope workers	17.0
General miner	13.1
Shift boss	12.9
Drillers	10.9
Winch transporter/Erector	0.8
Aquajet operator	0.8
Rigger and ropeman	0.3
Learner official	0.1

Table 4-4 shows the breakdown by occupation of those involved in scraper winch accidents. This analysis by occupation indicates that only five occupations are involved in 98% of the accidents due to the scraper winch system. The analysis also indicates that winch drivers (43,9%) are prone to scraper winch accidents. Surprisingly, 26% of personnel involved in scraper winch accidents are shift bosses and general miners, which was a concern for the research team. Scraper winch hazards winch needs to be highlighted to skilled workers, especially those in supervisory position.

Having explored the activity, time and occupations of those most frequently involved in accidents the main/significant causes of scraper winch related accidents needs to be explored.

4.3.1 Principal causes of accidents

A further analysis was conducted to investigate the main causes of scraper winch accidents from the SAMRASS database (1998 to 2002). Table 4-5 and Table 4-6 shows the distribution of significant causes of accidents within the selected data set. From the two tables it is clear that the main major causes are due to poor supervision, judgement and lack of adherence to safety procedures. The data also shows that "maintenance of standards" is a major cause of injuries (51%) and fatalities (31,3%).

Table 4-5: Causes of injuries related to scraper winch systems for the period 1998 to 2002

Cause (Injuries)	Percentage of total
Inadequate maintenance of standards	51.0
Lack of knowledge regarding safety aspects of the job	14.3
Poor judgement	9.7
Lack of practice under supervision	9.1
Poor coordination	4.8
Training programme inadequate	4.2
Inadequate method for hazardous task identification	2.8
Wrong/Sub-standard equipment	2.2
Procedure not used for training purposes	1.9

Table 4-6: Causes of fatalities related to scraper winch systems for the period 1998 to 2002

Cause (Fatalities)	Percentage of total
Inadequate maintenance of standards	31.3
Poor judgement	15.6
Procedure not used for training purposes	12.5
Lack of knowledge regarding safety aspects of the job	9.4
Available but not used	9.4
Training programme inadequate	6.3
No adequate system to prevent use of unsafe equipment	3.1
Lack of practice under supervision	3.1
Physical capability analysis not compiled/utilised	3.1
Procedures	3.1
Correct tools for task not available	3.1

Causes from Table 4-5 and Table 4-6 identified issues associated with control measures that were investigated further during the subsequent mine visits and risk assessment. These included:

- Maintenance of standards, procedures and systems to prevent usage of incorrect tools and equipment
- Training programme and its application to actual working environment.
- General knowledge and identification of the hazards.
- Management and supervision of safe working practices and procedures and the integration of other influences such as environmental conditions.
- The ability of current pre-use to pro-actively identify hazards and prevent accidents.
- Other factors that might influence judgement and coordination during operations.

4.4 Current Practice on South African Mines

In order to investigate further the hazards, controls & shortcomings, and potential causes of accidents associated with scraper winch operations, a number of visits were undertaken to gold and platinum mines, as well as equipment manufacturers.

The following fundamental questions regarding current practices required answers:

- ✍ Did the mine conduct any formal training, including awareness and identification of hazards and risk regarding the scraper winch systems?
- ✍ Did this training provide sufficient knowledge and skills regarding the operation of scraper winch equipment?
- ✍ Did the mines provide hazard and risk awareness regarding the scraper winch systems identification for all stope workers?
- ✍ Were training methods that were employed effective in ensuring that the trainees acquired the knowledge and skills with regard to both the technical and safety aspects of the scraper winch systems.
- ✍ Were scraper winch accidents a major problem for both the gold and platinum sector requiring further research, or was it a managerial and operational issue?
- ✍ Were there any specific research areas of the scraper winch system that needed special focus?

To answer these questions interviews and discussions were held with training, safety risk and production personnel at the mines. In addition, many hours were spent observing the training of workers and the underground operation of scraper winch systems. All discussions were open-ended in the sense that the formal questionnaire did not always have to be used. The research team used the findings of the data analysis and a specific list of questions to obtain answers to the above main questions.

In most cases, underground observation by the research team noted that 'rigging', 'signalling devices' and 'winch start-up warnings' were often not adhered to. Although these issues were dealt with in terms of the mine safety standards and procedures, underground visits indicated that mines fail to implement their own mine standards and procedures. During underground visits the following were observed:

Rigging

- Eyebolts and snatch block not installed to standards
- Snatch blocks not properly secured
- Damaged strands not cut off
- Dislodged eyebolts and pins not removed
- Unavailability of rig holes

Signalling devices

- Bell wire not connected to signalling device
- Compressed air supply not attached to air whistle
- Bell wire not easily accessible from both sides of the gully
- Bell wire snagged, fouled or obstructed
- Defective signalling devices
- Ineffective warning system

Winch started without warning

- Ineffective lockout system
- Scraper path not inspected (e.g. signalling device not tested prior to winch operation).
- Signal devices not in working order
- Ineffective start-up procedure
- Mining conditions and gully orientation almost invariably restrict the winch operator's line of sight to a few meters of the operator's position.

The research team drew several conclusions relating to potential causes of scraper winch accidents to supplement findings from the database. These were:

- Lack of adherence to standards
- Non-compliance with safe procedures
- Poor hazards identification/recognition skills
- Negligence by workers is the main cause of lack of adherence to standards
- Ineffective transfer method of hazard and risk awareness to all stope workers

4.4.1 Findings from mine visits

Rigging

To address the rigging problem one platinum mining group are investigating the possibility of importing the scraper rope due to better quality of the imported product. They are also using ‘roll splicing’, as opposed the usage of ‘loop splicing’ which is widely used by the mining industry. The main reason for this is that ‘loop splicing’ causes tensioning around the loop of the rope, which leads to the breaking of the rope during scraper operation. In addition, the group have developed snatch blocks ‘pins’ that are difficult to dislodge.

Signalling devices

Underground stope signalling devices are major problem for both gold and platinum mining sectors. Currently, suppliers and the mining houses are addressing the problem. Currently tests are being conducted on the ‘EMIS’ type winch-signalling device at various mines.

The signalling device is interlocked with the winch starter so that the motor is tripped when continuous signals are given. The supplier claims that the ‘EMIS’ type is about R100.00 more than the old signalling device if it is bought in the same batches as the old signalling devices. Diamond circle product (DCP) has also developed a similar prototype-signalling device.

The platinum mining industry is currently testing the ‘Accutrack’ type winch-signalling device. The system consists of a series of self contained, battery powered radio devices with a life of 6 to 8 months, depending on the length of the gully, costing approximately R 6000 per gully installation. They can be securely attached to the wooden support down the length of a scraper winch gully. A trigger unit is attached to the handle of a scraper winch. By means of the trigger unit, the safety status of the winch is relayed to all the gully units. Communication is initiated via the caplamp, to the photoreceptors on the surface of the unit. This signal is then relayed to the other units where the signal is transmitted to stope workers and winch drivers as an audible sound and visual light flashes. However, use of this system may be prohibitive to some mines due to the high installation and maintenance costs.

Winch started without warning

The DCP signalling devices include the lock out system of the winch and communication to the winch driver. The system may include the delay start of the winch motor and the sounding of an audible alarm and flashing lights prior to starting of the winch. The DCP system consists of a 'jack plug', which is used by the winch driver to unlock the system before starting the winch unlike the conventional 'pad lock' method that may be easily broken.

4.4.2 Findings from winch Supplier interviews

The research team decided to interview only the winch suppliers due to the high accident rate (?45% winch related accidents) at the winch position and the fact that the occupational accidents analysis indicated that 44% of the winch operators were prone to scraper winch accidents. Presently, three manufacturers, namely Exdin engineering, Diamond circle products and Pillman, are the main suppliers of winches for both platinum and gold mining sector.

Scraper winch manufacturer comments

One of the scraper winch manufacturers is mainly concerned about the usage of poor quality clutch bands, which often leads to accidents related to the winch handle. This is also because the winch clutch band is the biggest consumable component of the winch.

The indications were that the mines tend to develop their own winch stop arrangements and these arrangements may not allow two-way rotational direction, which can cause related winch handle accidents. They had long terminated the development of remote control and automatic winches due to high equipment and development costs.

Another scraper winch manufacturer is generally apprehensive about the winch being started without warning, the operator's line of sight and the signalling devices. Thus, it has developed the all-in-one electric system. The remote control winch consists of a signalling device which is connected to the winch electric power and consists of a ‘jack-plug’ lock out system. The benefits of the remote control are seen to be as follows:

- ✍ The operator can choose the best position from which to operate the winch.
- ✍ The operator can see the scoop and control it’s filling.
- ✍ The driver can see obstructions and so avoid many failures and delays.
- ✍ Clutch band wear is reduced due to correctly applied force.
- ✍ Accidents can be reduced or avoided by stopping the winch immediately should a dangerous situation arise.

The main concern of this remote control winch design is the increase in costs and the reliability of the new remote control system.

Winches have also been developed with a safety barrier, which protects the winch operator from being injured due to fouling and entanglement of the rope. The winch operator stands in the same direction as the motor (the motor is perpendicular to the drum), which provides sufficient clearance from the drum and this protects the operator from being injured by the drum and rope entanglement.

Remote controls have been developed and can be fitted on most makes of winches.

5 Risk Assessment and Human failure

Additional and/or more detailed results can be found in the following appendices:

Appendix 4: Generic risk assessment record
Appendix 5: Assessment of human failure potential

5.1 Generic Hazards

The generic hazards related to design, installation and operation of scraper winch systems were identified through undertaking a generic health and safety risk assessment. Table 5-1 contains a summary of generic hazards, according to risk rating, from the risk assessment record.

Table 5-1: A Summary of Hazards from the Generic Risk Assessment

Hazards with High Risks – 1 to 6
1. Struck by ropes in the gully or face
2. Struck by scraper scoop in the gully or face
3. Struck by scraper scoop in the winch cubby
4. Struck by snatchblock
5. Struck by rocks from bad hanging
6. Struck by falling winch
7. Struck by moving winch
8. Entanglement in the winch cubby
9. Entanglement
10. Struck by falling snatchblock during handling and installation
Hazards with Medium Risks – 7 to 15
11. Electrocution
12. Misfires in the winch cubby
13. Falling into tip
14. Hand punctured by rope strands
15. Struck by rope strands
16. Hand hitting hanging
17. Struck by rolling or moving rocks or dislodged items
Hazards with Low Risks – 16 to 25 (ALARP)
18. Struck by rope due to unexpected uncoiling or tensioning
19. Hands cut by bell wire
20. Entanglement from fouling between bell wire and ropes or scoops

From the list of generic hazards in Table 5-1, the following were considered to be the significant generic hazards related to the design, installation and maintenance of scraper winch systems:

1. Struck by winch;
2. Struck by ropes;
3. Struck by scraper scoops;
4. Struck by snatchblock;

5. Punctured by rope strands;
6. Entanglement

Detailed explanations of these hazards and conditions that are likely to influence their causes are outlined below.

5.1.1 Struck by winch

Winches are heavy equipment and accidents involving winches often result in fatalities or serious injuries. Being struck by a winch was identified as a significant hazard, with primary causes being falling and moving winches during their transportation, installation, operation or removal. Conditions likely to lead such to such accidents include:

- winches not installed to mine standards;
- inadequate pinning of winches to winch beds during installation, resulting in the movement of such winches when operated;
- use of inferior material such as cement, grout resin, pins, etc. during installation of winches;
- use of inappropriate tools to handle winches in confined spaces;
- non-compliance with standards and procedures to move winches safely;
- absence of procedures regarding temporary storage or packing of winches when moved from one place to area to the another;
- ineffective training or inexperience of new recruits;
- ineffective or absence of supervision;
- improper positioning when handling or moving of winches.

5.1.2 Struck by ropes

Being struck by ropes was identified as a significant hazard to all stope workers, with most accidents likely to result in serious injuries or fatalities. Rope accidents are primarily caused by:

- unexpected tensioning or uncoiling of ropes during their installation into drums;
- unexpected or sudden movement of ropes in the gully or face;
- broken or snapped ropes when subjected to pulling tension;
- fouling of ropes.

Conditions that are likely to predispose such accidents include the following:

- winches started without warning when there are people travelling, walking or transporting material along the gullies, or working in the stope face is a major concern in platinum mines. Some contributory factors to this are:
    - ineffectively trained or inexperienced operators;
    - untrained temporary operators in the absence of regular operators;
    - defective or ineffective winch lockouts;
    - production pressures leading to unsafe practices;
    - obstructed or restricted operators' line of sight;
    - ineffective or absence of supervision.

- communications – the most influential factor cited in most scraper winch system accidents was poor communications. The effectiveness of the current system involving a bell wire connected to a signalling device (air whistle) is usually affected by the following factors:
    - it is a one-way communication system, with no feedback to the person giving the signal;
    - bell wire not always connected to the signalling device;
    - compressed air supply not connected to the signalling device;
    - snagged, fouled or obstructed bell wire, particularly in long gullies;
    - gullies which are not straight in orientation;
    - defective signalling device;
    - bell wire not installed to both sides of the gully;
    - bell wire not installed to entire length of the scraper winch system path;
    - excessive noise from drilling operations.

- personnel positioning – the risk of being struck by ropes increased due to a failure:
  - by people to recognise hazards and adopt positions of safety. Most accidents often happened when people were sitting, waiting, observing, supervising or even sleeping (stationary positions) in improper positions along the gully or in the stope face;
  - by mines to train all stope workers in identification of hazards related to scraper winch systems.

- movement of people – the movement of people across gullies when scraping is in progress is a major concern in both gold and platinum mines. Most people are injured when attempting to cross a scraper path without following approved procedures. The problem is compounded by ineffective or absence of supervision, and poor communications.

- elevation of ropes – fouling of ropes occurs when they not properly elevated to mine standards, particularly where the paths of different scraper winch systems intersect.

5.1.3 Struck by scraper scoop

Being struck by a scraper scoop was identified as a significant hazard with accidents likely to happen in the winch cubby, along the gully or in the stope face. The primary causes of accidents were identified as:

- uncontrolled movement of a scraper scoop due to mechanical failure, resulting in the operator being struck by a scoop in the winch cubby;
- operator being struck by a scoop in the winch cubby when operating a winch with overlain ropes;
- unexpected or sudden movement of scoop in the gully or stope face;
- fouling of scoops, or between scoops and ropes;
- an accidentally derailed scoop.

Conditions that might lead to such accidents include:

- winches started without warning; poor communications; improper personnel positioning; movement of people across gullies when scraping is in progress; and improper elevation of ropes, as described in 5.1.2;
- absence of regular maintenance of scrapers – maintenance only undertaken when a breakdown is reported;
- ineffective barricades;
- material left in the scraper path; and
- ineffective training and/or supervision.

5.1.4 Struck by snatchblock

A snatchblock is a heavy, solid piece of metal and being struck by one often results in serious injuries or a fatality. It was recognised that being struck by a snatchblock is a significant hazard, with accidents caused primarily by:

- a falling snatchblock during handling and installation;
- a person's head hitting a snatchblock when walking or travelling along the gully;
- a dislodged or broken snatchblock when a scraper winch is pulling scoops.

The following conditions are likely to lead to accidents:

- ineffective training or inexperience with regard to safe handling and installation of snatchblocks;
- PPE not to mine standard;
- poor visibility;
- use of old and defective snatchblocks, and spares not readily available;
- improper positioning of personnel in the line of pulling or inside deflection areas;
- absence or ineffective supervision.

5.1.5 Punctured by rope strands

Scraper winch ropes are used in an environment in which they are exposed to wet conditions (water and mud), leading to quicker deterioration.

When deteriorated, ropes break more often requiring splicing to join them together. Strands are mostly found in damaged parts of the rope or at rope joints. Punctured by rope strands is a common occurrence in mines and was identified as a significant hazard. Punctures were often caused by:

- inadvertent handling of damaged ropes with protruding strands;
- inadvertent contact with moving ropes and getting punctured by rope strands;
- stepping onto ropes lying in the footwall and getting punctured by rope strands after;
- handling damaged ropes with protruding strands when slipping and falling.

Conditions that are likely to predispose such accidents include:

- PPE not to mine standard;
- Ineffective training on splicing techniques;
- substandard splicing of ropes;
- absence of or ineffective pre-use inspections;
- protruding strands left uncut;
- bad housekeeping;
- absence of or ineffective supervision.

5.1.6 Entanglement

Entanglement is a significant hazard and entanglement accidents, which often lead to fatalities, can be caused by either of the following amongst others:

- feeding of ropes into winch drums;
- coiling of ropes into drum during scraping operations;
- manual handling of ropes when ropes are being coiled into winch drums;
- ropes catching loose clothing while being coiled into winch drums;
- fouling of ropes and bell wire; and
- fouling of scraper scoop and bell wire.

Conditions that are likely to cause such accidents include:

- inexperience or ineffective training in feeding and coiling of ropes into winch drums;
- improper positioning when feeding ropes into winch drums;
- absence of or ineffective barricades and guards;
- use of incorrect tools;
- PPE not to mine standard;
- Bell wire not installed properly;
- Absence of or ineffective supervision and enforcement of legal requirements.

5.2 Assessment of Controls

The industrial interviews, mine visits and generic risk assessment conducted extracted a considerable amount of information regarding the effectiveness and reliability of control measures currently used in mines to reduce the levels of risk associated with hazards described in section 5.1. The range of controls and control shortcomings identified have been grouped and considered in terms of controls associated with the following:

1. Scraper winches;
2. Snatchblocks;
3. Ropes;
4. Personnel safety.

Control measures identified were further broken down into either engineering or operational controls:

- Engineering controls are predominantly those controls designed with the system to provide a barrier between the hazard and the employee; and
- Operational controls aim to reduce the exposure to hazards through procedures, instructions, training and competency.

The following is a discussion on the five groups of controls identified.

5.2.1 Scraper winches

Engineering controls

The following engineering controls were identified:

- Guards – guards are installed to cover the top of winch drums, and open couplings. They are meant to enclose ropes and other moving parts of winches. The aim is to protect operators from being dragged into the drum when coiling ropes. To minimise the danger of ropes catching loose clothing and pulling the operator into the winch drum, to prevent inadvertent contact with moving parts of machinery. The two most common types of guards are timber and bolt-on guards.

- Barricade – this is installed around the winch cubby to prevent inadvertent entry into the winch cubby and possible contact with moving machinery. Most barricades are built using fireproof timber, although some mines accept a chain barricade with suitable signage. In certain mines, a winch area barricade is also used as winch drums' guards. However, a common practice is to have both guards and barricades.

- Lockout device – a lockout device prevents unauthorised use of a winch when any repair work or maintenance is to be carried out, and when the winch is stationary. The lockout device makes the starter button inaccessible to unauthorised personnel, and appointed operators and their supervisors keep access keys. In practice, one operator keeps a key for one particular winch only. The responsibility of lockouts rests with winch operators, their supervisors, and other personnel such as maintenance crew, surveyors and grade samplers who may require that scraping operations be stopped to proceed with their work safely.

- Interlocks – these are used mainly in mechanically ventilated areas where an interruption in ventilation flows due to tripped fans could lead to a dangerous build-up of flammable gases, blast fumes and dust, and oxygen deficiency. Winches operating in such areas are locked with the ventilation fan supplying fresh air such that the power supply is cut off simultaneously with the fan stoppage. Interlocks decrease the likelihood of personnel proceeding with normal work activities under dangerous conditions.

Another type of interlock observed, locks the winch lockout device and a coloured bulb, located in the winch cubby, lights, usually bright red or green, such that the bulb is automatically switched on whenever a winch is stationary and not locked out.

Both types of interlocks are very rarely used in mines.

- Illumination of winch cubby – illumination of a winch cubby using a light bulb is still common in platinum mines, although it is no longer a legal requirement since Regulation 15.3.1 of the Minerals Act of 1991 was repealed. Illumination is meant to increase visibility in the winch cubby and reducing chances of accidents happening there.

The following shortcomings were identified with the above engineering controls:

- In most mines guards and barricades were either:
  - damaged and not maintained with gaps and discontinuities;
  - not located in the correct position to offer protection against identified hazards – in one particular mine a barricade was removed (with the knowledge of management) because it was too high and obstructing the operators field of vision;
  - removed during repair or maintenance work and simply left off;
  - put in place but not mounted securely;
  - not sufficiently robust.

- There were only a few areas in which lockout devices were functional, the majority were:

- simply left unlocked because of negligence, even in the presence of supervisors;
- left unlocked to give other operators access to the winch when responsible operator is given other duties – an operator tends to keep his/her own keys even if not working on the assigned winch for fear of loosing the keys; or
- broken or opened forcefully after keys to the device were lost or responsible operator is absent from work, and spare keys not available.

Operational controls

The following operational controls associated with scraper winches were identified:

- Procedures for winch bed preparation, winch installation, removal of winch from winch bed and transporting or moving winch from one area to the other – riggers and electricians are required during these tasks, while supervisors must check compliance with relevant mine standards.

- Pre-use inspection of winches – this procedure requires that a winch be inspected by operators prior to its use at the beginning of each shift and a checklist is provided for this purpose. A winch may not be operated until all safety standards have been met. In most mines, supervisors are expected to inspect winches at least once a week.

- Training – provided to persons on all aspects of operating a winch safely. After completing a training programme, a person is then appointed as a winch operator.

The following shortcomings were identified:

- Procedures:
    - supervisors do not always check that standards are complied with – winch cubbies not excavated or supported to standard, winch bed floors not flat, or winches not properly pinned to winch beds were observed;

- o riggers and supervisors are sometimes not present during transportation or movement of winches from one place to the other;
- o required tools and equipment such as chain blocks are sometimes not used to save time or unavailable due to shortage; and
- o no procedures for temporary storage or parking of a winch during transportation or movement from one area to another were identified;
- o pre-use inspections not always carried out routinely, checklists filled without doing any thorough inspections according to mine standard and not inspected by supervisors to take any corrective actions required. In one mine checklists were not even available in the stope.

- ✍ Certain training programmes differ with actual working procedures in mines; some mines do not have refresher training programmes or on-the job training; and most training programmes do not address hazards associated with the job. In some mines, there were allegations that people were buying certificates to operate winches without any formal training.

5.2.2 Snatchblocks

There were no engineering controls identified.

Operational controls

The following operational controls associated with rigging and snatchblocks were identified:

- ✍ Procedure for drilling of rig holes and installing sling eyebolts – this procedure specifies, amongst others, that the depth of the rig hole must be long enough to accommodate the entire length of the eyebolt, and that eyebolts to be used must be in a good condition and not have broken strands.

- ✍ Procedure for rigging a snatchblock – this procedure specifies the type of rigging to be used in particular ground conditions; the number of sling eyebolts to be used per snatchblock; installation of a safety sling or chain where applicable; installation and spacing of elevation snatchblocks; installation of deflection or return snatchblocks; and installation of a permanent snatchblock where applicable.

- Pre-use inspections– operators are expected to check the following: conditions of eyebolts; that all eyebolts are properly edged into holes, including the safety sling or chain; and that safety pins are in good condition and safely installed.

The following shortcomings associated with the above operational controls were identified:

- In some mines, standards do not specify the required depth of rig holes, and when they do, rig holes are sometimes not drilled to correct depth. In one mine, a very severely damaged eyebolt was used to rig a deflection snatchblock. The reason for this was that spares were not readily available when needed.

- Elevation snatchblocks are sometimes not spaced as required or not installed at all; worn out eyebolts, wedges and safety pins were being used in some mines; required number of eyebolts per snatchblock not always used; and some mines do not use safety slings or chains.

- Shortcomings related to pre-use inspections are discussed in section 5.2.1.

5.2.3 Ropes

No engineering controls associated with ropes were identified.

Operational controls

The following operational controls were identified:

- Coiling ropes into drums – a common procedure requires a snatchblock, placed in front of a winch, to be used when coiling ropes into drums. Ropes are to be guided into drums using a pinch bar, and not hands. In addition, PPE (gloves) must be worn at all times.

- The procedure for splicing ropes depends on the type of ropes to be joined together – old ropes together, new ropes together, or old rope to a new rope. Correct tools and PPE (gloves and goggles) must be used at all times.

- Pre-use inspections of ropes – operators are expected to check ropes that are passing through snatchblocks; to cut off worn out or damaged sections of the ropes and do splicing as required; and to cut off protruding rope strands.

- Training of scraper winch operators includes aspects or coiling and installation of ropes.

The following shortcomings were identified with the above operational controls:

- A snatchblock is sometimes not used when coiling ropes into drums; some operators use hands to guide ropes into drums due to a shortage of pinch bars or to save time; and working without the correct PPE is very common in most mines.
- Operators tend to use the easiest way of splicing ropes, irrespective of the type of ropes to be spliced, to save time – tying ropes into a knot resembling the figure eight; and protruding rope strands are rarely cut off.

- Shortcomings related to pre-use inspections and training are the same as discussed in section 5.2.1 above.

5.2.4 General personnel safety

This category of control measures is designed to deal with general personnel safety in the workplace.

Workplace design and engineering controls

Workplace design and engineering control measures are designed to provide a means of blocking any uncontrolled movements associated with scraper winch systems from reaching people. The following such control measures were identified:

- guards and barricades designed to prevent the unexpected or uncontrolled movement of scraper scoops and ropes from reaching operators.

The functioning of guards and barricades as hazards' control measures, and their shortcomings are discussed in full in section 5.2.1.

Controls designed to physically prevent people from adopting potentially unsafe positions or undertake activities where they are at risk

Identified controls include:

- demarcated areas of safety such as waiting places where people can go for protection when scraping operations are in progress;
- travelling ways alongside gullies and raises for use when scraping operations are in progress;
- grizzlies on top of tips, and handrails around tips prevent people from falling into tips;
- winch lockout devices prevent unauthorised access to winch starter buttons, and unintentional starting of winches;
- guards and barricades around moving parts of machinery such as winch drums, couplings and motors. These prevent people from being sucked into drums, and from inadvertent contact other moving parts of the machinery;

The following shortcomings were identified:

- in most mines people do not use designated waiting places but sit around their working places when scraping is in progress – along the gullies or raises, and in stope faces.;
- sometimes travelling ways do not exist or are obstructed; or situated on the wrong side to where people are positioned. In narrow stopes, most people travel in gullies and raises, and not in designated travelling ways because it is more convenient to do so, especially when one is carrying other material;
- in some mines, handrails around tips are not always installed; and
- shortcomings associated with guards and barricades, and winch lockout devices are discussed in section 5.2.1.

Controls designed to warn people and raise their awareness of areas or situations where they may be at risk

These controls include:

- automatic audible signals in remote-controlled scraper winch systems, an audible signal to restart winch after it was stopped, and slowly moved or flicked ropes provide a warning to people of intention to start scraper winch and hence scraping operations;
- verbal warnings from operators of intention to start a winch;
- clear fields of vision for operators, and visual contact between operators and other people reduce the risk of starting winches without proper warnings; and
- warning signs placed in entrances to gullies and raises where scraping operations are in progress, at tipping points and in winch cubbies provide warnings to people of surrounding hazards.

The following shortcomings associated with the above controls were identified:

- audible signals are sometimes not heard due to excessive noise from drilling operations, and flicking of ropes in long gullies can be ineffective;

- it is practically impossible for operators to give verbal warnings every time they are about to start a winch, and it is not a requirement but considered good practice where possible;

- fields of vision for operators in stopes is restricted to only a few metres from the operators' position, and visual contact is sometimes impossible due to orientation of winches to the gullies, stope faces and raises; and

- warning signs were either placed out of line of sight and hence not immediately gaining attention; written in language not understood by everybody; not legible or damaged and not maintained.

Procedures

The following range of procedures produced to ensure that people adopt positions of were identified:

- people not allowed inside 'dead man's corner' – triangular area formed by ropes at rope deflection points when scraping is in progress;

- people not allowed between blasting barricades and stope face during face scraping;
- people not allowed inside gullies, raises or stope faces when scraping is in progress;
- crossing of scraping path after stopping scraping operations temporarily using signalling devices (bell wires);
- stopping scraping operations for safety reasons during an emergency; and
- positioning of people during coiling of ropes into drums; working in tipping points; and walking around tipping points.

The following shortcomings were identified:

- the majority of safety procedures are not always followed because of pressures to achieve production targets. Sometimes people deliberately breached these procedures, even in the presence or with the knowledge of their supervisors and managers, or they were instructed to do so by their immediate supervisors. The lack of enforcement of procedures is also very common in mines. The following examples from one mine illustrate the point better:

    - Scraping operations were in progress with snatchblocks rigged to severely damaged eyebolts (with several broken strands) and the Miner, Production Supervisor and Mine Overseer were present and no action was taken. Written procedures stipulate that only eyebolts in good condition (with no strands) should be used to rig snatchblocks.

    - A deflection snatchblock, on the same scraper winch system as above, was rigged to only two eyebolts. Written procedures specify that three eyebolts should be used. The operator indicated that their problem was unavailability of eyebolts, but the supervisor nevertheless gave permission for scraping operations to continue.

    - The Production Supervisor was seen stopping the winch operator using lamp signals because the signalling device was damaged. Written procedures specify that no scraping is to take place until safety procedures are complied with.

The mines do not always comply with their own written safety procedures.

5.3 Human Failure Potential

Scraper winch systems are provided with a range of engineering and operational controls that reduce the potential for human failure. Nevertheless, the key to safe operations is linked to the elimination of human failure factors by operators and other workers who interact with scraper winch systems. The key to ensuring that human failure potential is as limited as possible and lies in a careful consideration of all human factors associated with the design, installation and operation of scraper winch systems and the immediate working environment.

The assessment of human failure potential identified the following human factors as being the most influential in reducing human failure potential in scraper winch systems:

5.3.1 Job factors

Control measures aimed at reducing human failure potential from job factors included the following:

- standards and procedures for each task associated with scraper winch systems;
- provision of tools and equipment;
- schedule of scraping operations (mainly during night shift); and
- design of working environment to ensure adequate space, access, lighting and ventilation.

The following shortcomings were identified as potential active failures as defined in Appendix 5:

- shortcomings in procedures as control measures are discussed in section 5.1.2 above. Many procedures only concentrated on what was to be done without indicating the hazards related to taking shortcuts, and non-compliance with procedures and standards;

- constant disturbances and interruptions, by people entering or crossing the scraping path, during scraping operations may irritate operators, particularly during day/morning shifts where there is no scheduled time for scraping operations and other activities;

- poorly maintained equipment – most mines did not have scheduled maintenance programmes for winches, it was only undertaken on a breakdown basis. There was no proper follow-up on pre-use checks/inspections such that remedial actions required were hardly done. In some cases, pre-use checks were rarely done. In addition, there was no objective measure of the life of ropes and the limits of deterioration acceptable, before ropes were changed;

- unavailability of correct tools and equipment. Most operators complained about the lack of equipment for critical tasks such as moving of winches and coiling of ropes into drums – chain blocks and pinch blocks respectively – leading to shortcuts and unsafe work practices;

- high workload – operators were sometimes given other duties not related to scraper winch systems and yet were still expected to do their prescribed jobs satisfactorily;

- unpleasant working environment – this may be due to excessive noise from drilling operations; inadequately ventilated areas excessively becoming hot; or confined spaces due to winch cubbies not blasted to standard dimensions;

- limited visibility and obstructed field of vision for operators due to support units or service pipes, amongst others, situated directly in front of winches;

- ineffective one-way communication between operators and other workers. Problems related to the current communication systems are discussed in section 5.2.1 above.

5.3.2 Individual factors

The following individual factors aimed at reducing human failure potential were identified:

- training programmes for operators – initial training for appointment as an operator; refresher training after a long leave; and on-the-job training under supervision; and
- medical fitness tests before workers are employed to work underground.

Shortcomings identified included:

- the following shortcomings associated with training were identified:
  - very little focus is placed on levels of skills and competence for operators;
  - some training programmes did not address general identification of hazards and risks for workers, such that perception and knowledge of these were very poor amongst many workers;
  - in many mines, experienced operators conducted on-the-job training for recruits, and supervisors hardly participated during such activities; and
  - there was also concern that some training programmes used procedures that were not similar to actual working procedures, especially were training for several mines/shafts/business units was centralised;

- there was no monitoring of personal performance on critical safety issues such as rigging and winch lockouts; and

- there were cases in which physical capabilities were not matching task requirements, and this was aggravated by that there was no health surveillance.

5.3.3 Organisation and management factors

In general, the reduction of human failure potential is achieved by good management of health and safety. This can be achieved through health and safety management systems such as Occupational Health and Safety Assessment Series (OHSAS) 18001 that contain organisation and management factors aimed at reducing human failure potential.

Shortcomings identified included:

- poor design and planning of working areas increased human failure potential, e.g. most gullies were found to be off-centre when required to be straight; and sometimes there were no travelling ways where required;
- certain mines did not have audits to monitor compliance with safety standards and procedures;
- inadequate and/or poor supervision – in some mines, supervisors were involved in 'risk taking behaviours' or encouraging unsafe work practices and behaviour (see section 5.2.4 for examples), thus, setting bad examples amongst their subordinates;
- inadequate staffing levels resulting in high workloads and production pressures, leading to unsafe practices or shortcuts to save time;
- imbalance between health and safety, and production goals (coupled with the need to achieve production targets at all costs); and
- poor assessment and management of risks associated with scraper winch systems in that:
    - risk assessments were not conducted at all in certain mines;
    - risk assessments were conducted to satisfy the legal requirements but not used as a safety management tool – not linked to standards, procedures and training programmes; or
    - risk assessments conducted and results not communicated to all stakeholders.

6 A Review of Regulations to scraper winch systems

The following shortcomings and information were found from the review of Regulations (Appendix 6):

? Regulations applicable to scraper winch systems are contained in Chapter 19 of the Minerals Act of 1991. However, there is a need to refer or cross-refer to other chapters of the Minerals Act in order to get the full understanding of the legal requirements. This cross-reference creates confusion and excuses not to comply with all the legal requirements;

? Regulation 19.3.3 requires a gentle flicking of ropes when starting a winch, however, this procedure is sometimes ineffective in long gullies. A distinctive audible signal, as prescribed in Regulation 19.2.2 should be considered;

? Regulation 19.5 calls for proper rigging of snatchblocks, but does not define what "proper" means. This is left to the person appointed in terms of Regulation 2.13.2 or the engineer, and explains the huge variation in standards and codes of practice in mines;

? The appointment of a person under Regulation 2.13.2 to be in charge of machinery can create confusion, leading to an overlap in areas of responsibility between the appointee and the engineer and neither of them knowing their responsibilities. However the move towards appointment of "Production Engineers" or "Horizontal Transport Managers" is helping alleviate the problem;

? Chapter 19 does not address how scraper ropes must be installed to prevent rubbing against timber supports with the resulting fire hazard. However, Regulation 11.3.8 which caters for this, can be interpreted as being applicable to scraper winch systems as well;

? Regulation 15.3.1 which requires illumination of machinery has now been repealed, but this practice is still considered good practice by many people; and

? In Chapter 19, mention is not made of guarding of scraper winches and the Regulations do not define a "proper" guard. It is left to the engineer or appointee in terms of Regulation 2.13.2 to prescribe in standards or code of practice.

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7 Conclusions

7.1 Analysis of SAMRASS database

- Scraper winch accidents in the gold sector account for 5% and 9% for platinum within all underground mine related accidents.
- There is an increase in the fatality rate for platinum sectors with a decrease in the injury rates for both the platinum and gold sector between the periods of 1988 to 2002.
- The most significant hazards associated with scraper winch systems in the gold sector are due to the scraper/scoop, whilst scraper winch rope accidents are significant for both the platinum and gold sector, in that order.
- Most injuries occur during the morning shift, whereas most fatalities occur during night shifts. This may be due to poor supervision, which might lead to sub-standard conditions on the night shift.
- The following summarises the major activity categorisation of all the different scraper winch accidents
  - Rope related accidents***:*** Rope striking workers etc. is significant for both the gold (25%) and the platinum (23%) sectors.
  - Snatch block related accidents**:** Eyebolt/Snatch block coming out represents more than one-third of all accidents for both gold and platinum.
  - Winch related accidents***:*** Drum/Rope entanglement is significantly high for both platinum (49%) and gold (40%) sector. The winch being started without warning (26%) significant in platinum compared to the gold sector.
  - Scoop related accidents***:*** Workers being struck by the scoop is significantly high in platinum (37%), but there is no clear explanation to the cause of accidents from the SAMRASS database.
- People most prone to the accidents: Activity at the time of accident analysis indicates that winch operators, stope workers, general miners, shift bosses and drillers are most prone to scraper winch accidents, in that order. Shift bosses and miners are involved in accidents during supervision of the crew, due to fouling of the rope, incorrect positioning and while travelling in the stope.

- ✍ Injuries occur at the beginning of the morning shift when most workers in groups commute to their work places and fatal accidents occur mostly during night shifts when there is less or poor supervision; and loss of concentration and awareness amongst workers.
- ✍ Principal causes of scraper winch accidents are due to:
  - o Poor adherence of standards, procedures and systems to prevent usage of incorrect tools and equipment
  - o Training and its practical application to the actual working environment
  - o Poor hazard identification skills and perception of risks
  - o Management and supervision of safe working practices and procedures.

7.2 Mine and Supplier interviews

A current study in the South African mining industry indicates that rigging, signalling devices and winch started without warning are the significant causes of scraper winch accidents. The manufactures and suppliers have recognised the risk associated with current winch design, installation and operational procedures of the scraper winch systems, thus there are current developments in the scraper winch systems.

In conclusion, the scraper winch standards as a whole are comprehensive but not well integrated into the production environment although there are some gaps in the mine standards and procedures of the scraper winch system for different mining operations. The suppliers can developed any suitable system to improve the safety of scraper winch systems, however the development is dictated by the mining houses and cost benefit analysis. The mine audits confirmed the findings from the analysis of the SAMRASS database that negligence and non-adherence to established standards is the main reason for accidents involving scraper winch systems.

7.3 Risk Assessment

Risk assessment was introduced into the South African mining industry in 1996 by the Mine Health and Safety Act, which required every employer to assess and respond to risk in the workplace. According to SIMRAC (1997) there are three types of risk assessments, namely:

- baseline risk assessment – identification of boundaries and major risk areas for future detailed risk analysis;
- issue-based or pre-emptive risk assessment – associated with a system of management of change, or a detailed risk assessment on one specific issue or system of operation; and
- continuous or routine risk assessment – integral part of day-to-day management and includes audits, pre-use inspection checklists and general hazard awareness programmes.

It is clear from the above that mines should conduct issue-based risk assessments on scraper winch systems, particularly after major accidents or incidents, and routine risk assessment should be incorporated into daily management of safety. Some mines are already doing this, but in certain sites no evidence could be found that risk assessments have ever been conducted on scraper winch systems. Pre-use inspections/checklists and audits, where they are done, are not used as opportunities to make people aware of hazards in their workplaces but to satisfy mine requirements only.

For a risk assessment based approach to accident reduction to be effective, the first requirement is that it is actually done. The legal requirement for a risk assessment is that findings of such an assessment should be communicated widely to all stakeholders involved to make them aware of major risks facing them in their workplaces. Working standards, procedures and training programmes should then be based on risks identified through risk assessments. This was found to be the case in only one mine. Although other mines claimed that they followed the same approach, there was no evidence to support this.

A 'suitable and sufficient' risk assessment is determined largely by the quality and suitability of the hazard identification and risk control process employed. A typical risk assessment must involve the following steps:

1. Identify potential hazards;
2. Identify control currently in place;
3. Identify control limitations;

4. Assess the risk; and
5. Improve controls.

The documented example of the risk assessment facilitated by the project given in Appendices 2 – 4, illustrate the methodology to be followed and the level of detail likely to be required within a risk assessment in order to effectively address the significant hazards that currently exist. The documented example can be used by mines as a reference to ensure that significant potential hazards and relevant controls associated with the design, installation and operation of scraper winch systems are not overlooked by mine risk assessment teams. However, based on the few mine risk assessments seen during the project, it can be concluded that the majority of mine personnel have little or no difficulty in identifying potential hazards or the controls that should currently be in place.

7.4 Significant Generic Hazards

The project identified the following six significant generic hazards related to the design, installation and maintenance of scraper winch systems:

1. Struck by winch – primary causes being falling and moving winches during their transportation, installation, operation or removal;
2. Struck by ropes – primarily caused by unexpected tensioning or uncoiling of ropes during their installation into drums; unexpected or sudden movement of ropes in the gully or face; broken or snapped ropes when subjected to pulling tension; and fouling of ropes;
3. Struck by scraper scoops – primary causes of accidents were identified as uncontrolled movement; operator being struck by a scoop in the winch cubby when operating a winch with overlain ropes; unexpected or sudden movement of scoop in the gully or stope face; fouling of scoops, or between scoops and ropes; and an accidentally derailed scoop;
4. Struck by snatchblock – caused primarily by a falling snatchblock during handling and installation; a person's head hitting a snatchblock when walking or travelling along the gully; and a dislodged or broken snatchblock when a scraper winch is pulling scoops;

5. Punctured by rope strands – caused by inadvertent handling of damaged ropes with protruding strands; inadvertent contact with moving ropes and getting punctured by rope strands; punctured by rope strands after stepping onto ropes lying in the footwall; and handling damaged ropes with protruding strands when slipping and falling; and
6. Entanglement – can be caused by feeding of ropes into winch drums; coiling of ropes into drum during scraping operations; manual handling of ropes when ropes are being coiled into winch drums; ropes catching loose clothing while being coiled into winch drums; fouling of ropes and bell wire; and fouling of scraper scoop and bell wire.

A number of control measures designed to reduce the above mentioned significant hazards were identified during the project. However, the key to effective reduction of risks from identified hazards lies in the identification of control limitations and the implementation of improvements or additional controls required to reduce risk to a level that is as low as reasonably practicable. The majority of control limitations and human factors that may contribute to potential human failures identified during the project arose from shortcomings or problems in the following areas:

- ***Rules and standard procedures:*** In many cases, mines had produced generic procedures to cover all their business units or shafts, but due to differences across installations of scraper winch systems, these were either impractical or too general to be of value at the individual installations. In some cases, mines identified critical tasks in scraper winch systems but did not address them in their safe standard procedures. In other cases, recommended guidelines on safe standard procedures issued by corporate offices differed with those at the individual mines, resulting in confusion. To be fully effective and encourage high levels of compliance, rules and procedures need to be both practical and relevant to the operation they are designed to address. Generic procedures and guidelines across all business units, mines or shafts may provide a good starting point but they must be checked against each of the operations they are designed to apply to and modified where necessary.

- ***Training:*** Once such effective standard procedures have been produced, they must be effectively communicated to the relevant members of the workforce through training. For such training to be effective, trainees should not only be instructed in the procedures to be followed, but should also be made aware of the potential hazards and risks these procedures are designed to mitigate and hence, the risk they face if these procedures are not applied in practice. A general hazard awareness programme on all aspects of scraper winch systems should also be conducted for all workers who interact with these systems directly or indirectly. In general, results of a comprehensive risk assessment, such as the one conducted during this project, should be the basis for identifying training needs and setting training objectives. Where training for a number of business units, mines or shafts, the training programmes must take cognisance of the rules and standard procedures in different operations.

- ***Inspections:*** Once a scraper winch system is installed, the only inspection conducted on it is the pre-use inspection by operators at the beginning of every shift. Shortcomings with pre-use inspections as a control measure have already been discussed elsewhere in this report. The major concern is that mines do not have regular or scheduled maintenance programmes for winches, it is only undertaken on a breakdown basis. In some cases, there was no proper follow-up on pre-use checks/inspections such that remedial actions required were hardly done. In addition, there was no objective measure of life of ropes and limit of deterioration acceptable before ropes were changed, only a visual inspection. There is too much dependency on the judgement of operators. The effectiveness of pre-use inspections is therefore very questionable.

- ***Communication / Signalling systems:*** The most influential factor cited in most accidents in scraper winch systems was poor communications. The effectiveness of the current system involving a bell wire connected to a signalling device (air whistle or light bulb) is usually affected by a number of factors as cited elsewhere in this report. The biggest concern is that it is a one-way communication system, with no feedback to the person giving the signal. Because of this ineffectiveness, workers use alternative informal signals such as the use of headlamps. This becomes a problem when there are new recruits or other workers not familiar to the ‘signals’. Improved communications is seen as one of the areas that might significantly contribute to improved safety of scraper winch systems.

7.5 Regulations review

It is evident that Regulations on scraper winch systems need to be revised, a process that is already underway, and improved controls put in place. A document to give guidance on adequate controls and applications of best practice is also needed.

7.6 Summary

The project has demonstrated how a simple subjective risk assessment process can be used effectively to identify and address the significant hazards and risks associated with scraper winch systems. To successfully achieve this, cognisance must be taken of the human factors that contribute to the potential for human failure. Mines are encouraged to conduct their own risk assessments on scraper winch systems, and Appendices 2 - 4 should provide the necessary guidance in this regard.

In conclusion, the study of the SAMRASS database and mine visits undertaken by the research team indicates strongly that scraper winch systems are a problem in the gold and platinum mining industry representing 5% to 9% of all underground accidents. The analysis indicates that scraper winch accidents are primarily a managerial and operational issue, and no further research is required. Mining houses must continue to be diligent to ensure that standard are implemented and enforced. Furthermore, risk assessment need to integrated with mine standard

8 Recommendations

It became clear to the research team that the recommendations for scraper winch accidents are for managerial and operational level. The significant deliverable is the risk identification and hazard recognition, and communication techniques at an operational level. Thus, the following are recommendations are made:

- Further research into “soft issues” is needed
- Review the starting-up procedures of scraper winch systems.
- Put in place effective warning devices i.e. better communication between workers and the winch operators.
- Review underground stoping layouts such that workers are separated from the scraper path.
- Improve upon standards e.g. winch installation and transportation
- Review rope splicing i.e. loop splicing versus roll splicing.
- Review of coiling mechanism of the winch system
- Improve winch operator ergonomics due to confined stoping environment.
- Ensure that behaviour based safety programmes are focussed not only on workers, but also on front-line supervisors and managers. The mining industry must take cognisance of the human factors that contribute to the potential for human failure.

9 SAMRASS data shortcomings

The initial findings of this research report were directly influenced and guided by an analysis of the data extracted from the SAMRASS database. The research team felt that whilst the format of this data might be suitable for technical analysis it has some distinct shortcomings in terms of causes of accidents and activities of injured person (behavioural research). The following shortcomings were identified from the SAMRASS database:

- Information is often vague.
- There is no identification of who was responsible for the cause.
- The existing data provides inadequate insight into circumstances of the accident. A researcher can only infer what the situation might have been.
- Duplicate codes in terms of activities.
- Incomplete information is provided about the activity of injured person.

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Appendix 1: Scraper winch Questionnaire

The specific set of questions was designed to guide the mine visits. They provide much of the background information on how does the gold and platinum sector perceive the scraper winch accidents. The main conclusions were drawn from the actual observation of underground environment at each site.

Typical questions asked

- ✍ What major problems have you experienced regarding scraper winch systems in the past five years?
- ✍ How did you address the above-mentioned problems?
- ✍ Have you conducted any risk assessment on scraper winch systems and what were the findings of such an assessment?
- ✍ Is there any formal training, including awareness and identification of hazards and risks, on scraper winch systems?
- ✍ Do you have a hazard and risk awareness and identification program on scraper winch systems for all stope workers?
- ✍ How are your training programs related to actual working standards, procedures and practices?
- ✍ Is there any between the safety, risk, and training departments? Explain.
- ✍ What do you think could be done to improve the safety of scraper winch systems?
- ✍ Which areas of the scraper winch systems, if any, require further research?

Appendix 2: Generic Risk Assessment Methodology

The generic risk assessment methodology was based on the routine risk assessment process illustrated in Figure A2:1.

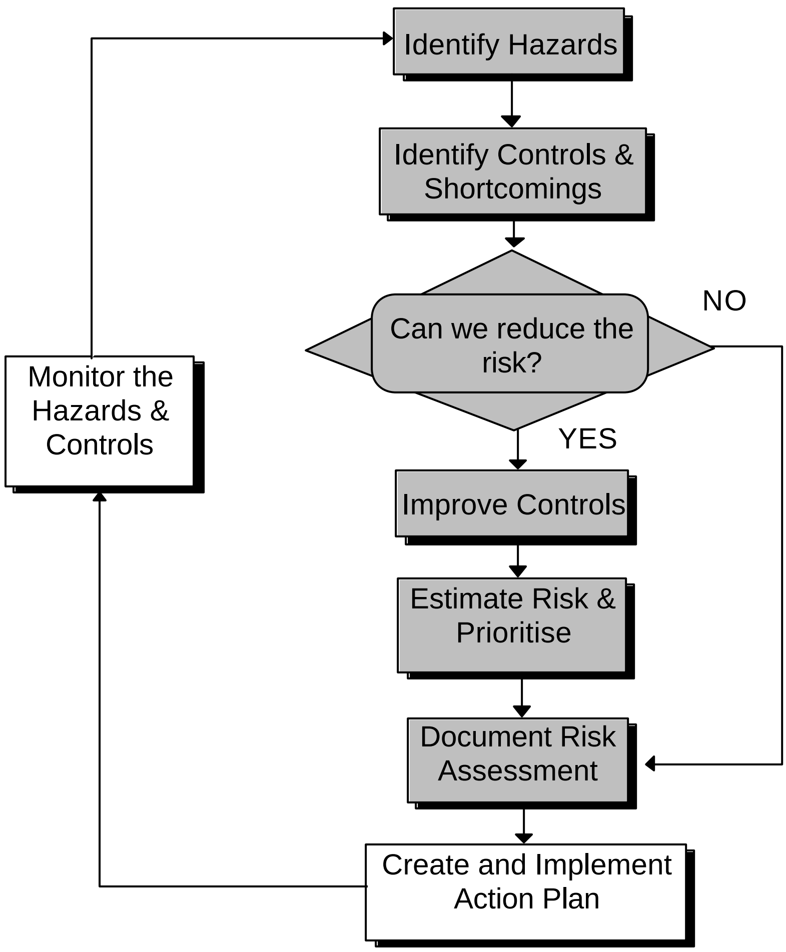


Figure A2: 1 Routine risk assessment

1. Preparation

The preparation stage involved collection of relevant paperwork and documents, and identification of people with relevant skills and experience to participate in the risk assessment. A generic risk assessment workshop, facilitated by the research team, was then held.

2. Identification and scoping of boundaries of the assessment

The risk assessment process was designed to examine scraper winch systems in gold and platinum underground mines. A location-based approach was followed in identifying boundaries and these included stope faces and back areas, strike gullies, center gullies, raises/winzes and tipping points/orepasses.

The following format was used to document the health and safety risk assessment as shown in Table 0-1.

Table 0-1: Recording the health and safety risk assessment

Potential Hazard	Current Controls	Control Shortcomings	P	C	Risk	Comment
Note 2	Note 3	Note 3	Note 4			Note 5

3. Identification of hazards (Note 2)

According to the MHSA, a hazard is *'a source of or exposure to damage'*. It means anything with the potential to cause harm or damage to persons or equipment, arising from work or work activities. The risk assessment team identified hazards by examining each task and activity related to scraper winch systems in the above-mentioned locations, and using their own experience of the system under consideration.

Tasks considered included those associated with the installation and operation of scraper winch systems. All significant potential hazards and their causes were identified and documented.

4. Identification of controls and control shortcomings (Note 3)

Controls are any measures designed to reduce the likelihood of a hazard occurring, or the severity of harm that may arise if it occurs. This stage involved identifying all control measures in place to reduce the risk of the hazard occurring, and any shortcomings associated with such controls and hence reducing their effectiveness.

Current control measures were systematically identified using standards provided by the mines, the legal requirements and the experience of the risk assessment team. Limitations from environmental, ergonomic and human factors were also considered at this stage. Control shortcomings were mainly identified through observations made during underground mine visits.

5. Assessment of risk (Note 4)

The risk matrix used was derived as discussed below. For each potential hazard, a subjective estimation was made on the likelihood of such a failure using the following scale:

Likelihood of Failure	
A	Common occurrence
B	Has Happened
C	Could Occur
D	Not Likely To Occur
E	Practically Impossible

The most likely consequence or severity of the hazard occurring was then determined for each potential hazard, using the following scale:

Most Likely Consequence	
1	Multiple Fatals
2	Fatal
3	Serious Injury
4	Lost Time Injury
5	Minor Injury

The risk matrix shown Table A2:1 is a combination of estimates of likelihood and consequence.

Table A2:1 Risk Ranking Matrix

		Probability				
		Common Occurrence	Has Happened	Could Occur	Not Likely To Occur	Practically Impossible
Consequence		**A**	**B**	**C**	**D**	**E**
Multiple Fatals	**1**	**1**	**2**	**4**	**7**	**11**
Fatal	**2**	**3**	**5**	**8**	**12**	**16**
Serious Injury	**3**	**6**	**9**	**13**	**17**	**20**
Lost Time Injury	**4**	**10**	**14**	**18**	**21**	**23**
Minor Injury	**5**	**15**	**19**	**22**	**24**	**25**

Note:

High Risk - 1 to 6

Medium Risk - 7 to 15

Low Risk - 16 to 25

Appendix 3: Tasks Related to Scraper Winch Systems

In conducting the generic risk assessment, hazards were grouped according to tasks related to installation and operation of scraper winch systems. Some tasks were, however, grouped together due to their similarity or similarity of hazards associated with such tasks.

The following tasks or groups of tasks were considered in order of appearance:

1. Winch Bed Construction – footwall or concrete bed;
2. Winch Transportation, and Scoop Transportation – from area to another;
3. Winch Installation, and Winch Removal – installing onto or removal from winch bed;
4. Rope Installation – into winch drums;
5. Rope Splicing – joining of ropes;
6. Rigging and snatchblocks – installation of snatchblocks;
7. Electrical Installations – connecting winch motors to power source;
8. Winch Operation – actual scraping operations, including preparation for;
9. Tipping – into tip or orepass in the gully or raise;

Signalling – communication system.

Appendix 4: Generic Risk Assessment Record

POTENTIAL HAZARDS	CONTROL MEASURES	CONTROL SHORTCOMINGS	PROBABILITY	SEVERITY	RISK	COMMENT
1. Winch Bed Construction						
Struck by rocks from bad hanging	Permanent winch bed support to standard Visual examination Inspect/bar down prior to commencing any work as covered by standards, special instructions and legal requirement PPE to mine standard Supervision	Support not installed according to mine standard Inadequate visual examination or none conducted at all Inadequate barring Barring not conducted at all Inexperience and no training Adequate PPE not available PPE not always worn Supervision not always present	B	2	**5**	Existing controls are adequate but need to be enforced

2. **Winch or Scoop Transportation**						
Struck by falling winch or scoop: due to handling of a heavy equipment in a confined space from temporary storage or parking position	Use of correct equipment handling tools Winch or scoop transported as per mine standard – using rig chains or other winches Training on safe transportation Transportation under supervision of qualified rigger	Correct tools not always available Standards and procedures not adhered to Procedures impractical at times Untrained and inexperienced Supervision by a rigger is not always present	B	2	**5**	Most standards do not address moving/transportation of a winch or scoop and safe positioning during such an operation Better techniques or methods of transporting winches and scoops are required
	None	Winch or scoop stored or parked improperly and unsafely	B	2	**5**	There are no standards to address how winches and scoops are to be stored temporarily during transportation from one place to other

3. **Winch Installation or Removal**						
Misfires when drilling holes for pinning of winch	Pre-examination of winch bed area according to mine standards Supervision Training	Inadequate examination Examination not always carried out Supervision not always present Inexperienced or not properly trained	C	2	**8**	
Struck by winch due to handling of heavy equipment in a confined space	Use of correct equipment handling tools Winch or scoop moved as per mine standard – using rig chains or other winches Winch cubby excavated to recommended size Training on safe handling Working under supervision	Correct tools not always available Standards and procedures not adhered to Procedures impractical at times Winch cubbies often too small Untrained and inexperienced Supervision not always present	B	2	**5**	Most training programs do not address proper positioning and handling of heavy equipment such as winches

4. **Rope Installation**						
Struck by rope due to rope uncoiling or tensioning unexpectedly	Training	Not properly trained Untrained	B	5	**19**	Most mines have no control measures in place
Entanglement when feeding rope into drum	Ropes to be fed into winch drums when persons are standing in front of winch barricades Training on safe feeding of ropes	Winch barricades not always installed Not properly trained Untrained	B	2	**5**	
Hand punctured by rope strands when handling ropes	PPE to mine standard Rope strands to be cut off as per mine standards	PPE worn out Adequate PPE not always provided Rope strands rarely cut off	A	5	**15**	The use of worn out or inappropriate PPE in mines is very common

5. **Rope Splicing**						
Hand punctured by rope strands when handling or joining ropes	Use of correct rope handling tools PPE to mine standard Rope strands to be cut off as per mine standards	Correct tools not always available Worn out PPE PPE not available Rope strands rarely cut off	A	4	**10**	
Struck by strands when breaking ropes	PPE to mine standard Training on safe breaking of ropes	PPE not always available Untrained and inexperienced	B	4	**14**	It is not uncommon for rocks to be used in breaking ropes

Struck by rope due to: fouling of ropes in the gully	Rope installation and elevation to mine standards Supervision Training on standards and procedures	Ropes not always properly elevated Supervision not always present Non-compliance to standards Not properly trained or inexperienced	A	2	**3**	
winch started without warning	Start-up procedure available Winch lockouts to mine standards Supervision	Ineffective in long gullies Untrained, inexperienced or not appointed Winches not always locked out Lockout procedures impractical Ineffective/defective locks Supervision not always present	A	2	**3**	Management of keys for winch locks is a serious problem in mines and often leads to non-compliance with standard

6. Rigging and Snatchblock						
Struck by falling snatchblock during installation	Training on safe handling and installation PPE to mine standard Visual illumination using headlamps	Not properly trained or inexperienced Too heavy to handle safely PPE not always supplied PPE worn out Inadequate visual illumination	A	3	**6**	There is a general feeling that a snatchblock is too heavy to be carried by one person, although this is a common practice in mines
Struck by ropes when winch is started without warning during installation	Start-up procedure available Winch lockouts to mine standards Supervision	Procedure can be ineffective in long gullies Untrained or inexperienced Winches not always locked out Lockout procedures impractical Ineffective/defective locks Supervision not always present	A	2	**3**	This occurs when a strike gully winch system is opened when work on the face winch system is in progress, or vice-versa

7. **Electrical Installations**						
Electrocution: during installations or fault finding	Trained and competent staff, authorized and appointed	Not always to standard Inexperienced	C	2	**8**	
due to tampering	All panels and live conductors enclosed Warning notices	Panels usually left open after maintenance work Notices not always installed Illiterate workers	C	2	**8**	

8. **Winch Operation**						
Electrocution from contact with water and live conductors	All panels and live conductors enclosed Winches installed on updip side Gullies excavated to recommended size	Damaged cables not replaced or repaired Some winches on downdip side Gullies not to standard Gullies not always cleaned	D	2	**12**	In some mines winch operators are known to have been electrocuted from improperly grounded electrical installations
Fire from ropes coming into contact with wooden barricades or timber support	Fire proof No ropes against timber support		D	3	**17**	

Entanglement due to: coiling of rope into drum	Winch guards Winch area barricades	Damaged and ineffective Not always installed Often not replaced after maintenance work Inadequate supervision Not always installed Damaged and ineffective Often not replaced after maintenance work Inadequate supervision	B	2	**5**	Winch barricades are sometimes seen as obstructions to the winch operators' line of sight, and hence removed
manual handling of rope when rope is being coiled into drum	Use of correct tools Manual handling of ropes in rotating drums prohibited	Correct tools not always available Standard not always enforced Untrained, not appointed or inexperienced Supervision not always present	B	3	**9**	
rope catching loose clothing whilst being coiled into drum	PPE to mine standard and legal requirement Training Supervision	Proper PPE not supplied Standard and regulation not always enforced Untrained, inexperienced or not appointed Supervision not always present	B	2	**5**	
Injuries from hand hitting hanging because of confined space around winch cubby or due to stope closure	Winch cubby excavated to recommended size	Winch cubbies often too small	B	4	**14**	

Struck by scraper scoops in the winch cubby due to: overlain ropes	Winch barricades to standard Training	Damaged and ineffective Often not replaced after maintenance work Not always installed Untrained, inexperienced or not appointed	B	2	**5**	In most mines ropes are underlain, except where the geometry of the area makes it difficult to elevate ropes from an underlain position
mechanical failure	Pre-use inspection Regular maintenance	Illiterate operators Inexperienced, untrained or not appointed Sometimes ignored No follow-up on remedial action No monitoring or supervision Maintenance not done regularly Breakdown maintenance only	B	2	**5**	
Struck by ropes or scraper scoops while: walking, travelling or transporting material along the gully	Separate travelling ways Winch start-up procedure Persons not allowed in gullies when scraping is in progress Supervision	Separate travelling ways not always provided or obstructed Winch started without warning Start-up procedure ineffective in long gullies Untrained, not appointed or inexperienced operators Untrained Lack of knowledge Supervision not always present	A	3	**6**	The main problem area is poor or ineffective communication between general stope workers and winch operators

crossing or entering gully	Procedure to enter gully while scraping is in progress Supervision	Untrained and lack of knowledge Unawareness Poor or ineffective communication Supervision not always present	A	3	**6**	
working in the gully or face	Winch start-up procedure Persons not allowed to work in face or gully while scraping is in progress Supervision	Winch started without warning Start-up procedure ineffective in long gullies Untrained, not appointed or inexperienced operators Untrained and lack of knowledge Supervision not always present	A	3	**6**	
observing, waiting, supervising or sleeping (stationery positions) in the gully or face	Training on proper positioning Sleeping is not allowed Supervision	Improper positioning Training does not address hazard identification Untrained or inexperienced Poor enforcement and supervision Supervision not always present	B	2	**5**	

Struck by ropes when: ropes break or snap	Pre-use inspection Splicing to standard Replacement of old ropes	Inexperienced or untrained Inspection not always done No monitoring or supervision Untrained or inexperienced No supervision No guidelines on when to replace New rope not readily available	B	2	**5**	There are no guidelines on when to replace old ropes and life of ropes in general – all these are left to the operators' judgements
ropes foul each other	Elevation of ropes to standard	Ropes not elevated to standard Ropes not elevated Untrained or inexperienced workers No supervision	B	2	**5**	
Struck by moving winch	Pinning of winch to winch bed to standard Supervision	Winch not installed to standard Supervision not always present	B	2	**5**	
Struck by snatchblock when dislodged or broken	Rigging to standard Training Supervision Replacement of old or defective snatchblocks	Rigging not always to standard Untrained or inexperienced Supervision not always present Spares not readily available	B	2	**5**	

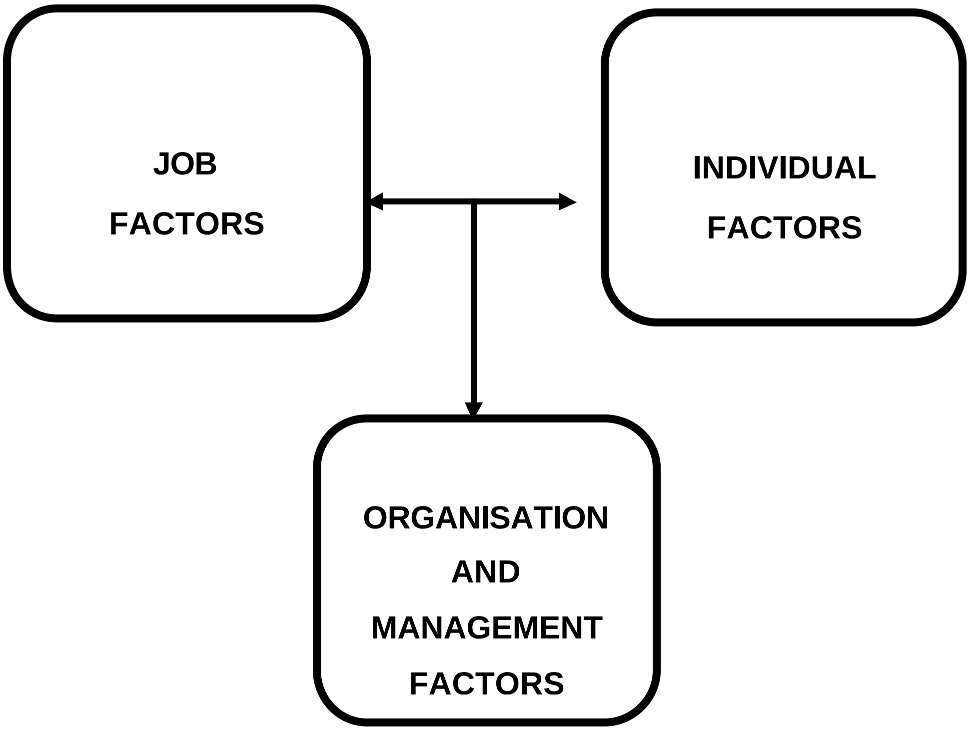
Struck by moving or rolling rocks, or dislodged items (such as support units and blasting barricades)	Positioning of gullies and faces to standard Training on proper positioning during scraping operations Supervision	Off centre gullies Ideal positioning impractical due to geology of area Training fails to address hazards related to improper positioning Supervision not always present	B	4	**14**	
9. Tipping						
Falling into tip while clearing blocked tip	Tip grizzly or barricade to standard Illumination Use of safety belts in tips Supervision	Not always installed Damaged and ineffective Tip area not adequately illuminated Not provided Supervision not always present	C	2	**8**	
10. Signalling						
Hand injuries when fingers are cut by bell wire	PPE to standard	PPE worn out or not provided	C	5	**22**	
Entanglement due to: fouling of ropes and bell wires	Installation of bell wire to standard Supervision	Poor installation – not tight Improper installation – not installed outside gully Untrained and inexperienced workers Supervision not always present	C	5	**22**	

scraper scoop catching bell wire	Installation of bell wire to standard Supervision	Poor installation – not tight Improper installation – not installed outside gully Untrained and inexperienced workers Supervision not always present	C	5	**22**	

Appendix 5: Assessment of Human Failure Potential

Human failures in the workplace are caused by human factors. According to the United Kingdom (UK) Health and Safety Executive (HSE) Books (1999),
'Human factors refer to environmental, organisational and job factors, and human and individual characteristics which influence behaviour at work in a way which can affect health and safety.'

Based on the above definition, human factors can be divided into three aspects – job factors; individual factors; and organisation and management factors – that interact with each other continuously as indicated in the figure below.



Human Factors in Occupational Health and Safety

Consequences of human failures can be immediate or delayed.

- *Active failures* have an immediate consequence to health and safety, and are usually made by front-line people such as machine operators. Job and individual human factors are often the immediate and contributory causes for active failures.

- *Latent failures* are the root causes of active failures, and are made by people such as managers and decision makers in an organisation. They are typical failures in health and safety management systems. Latent failures provide a great danger to health and safety, and are usually hidden within an organisation until they are triggered by an event likely to have serious consequences. Organisational and management factors are examples of causes for latent failures.

- There are two different types of human failure:
- human errors – human errors are actions or decisions, which were not intended, which involved deviations from accepted standards, and led to undesirable outcomes. Errors fall into three categories:
  - slips – failures in carrying out the planned actions of a task;
  - lapses – forgetting to carry out an action, or what was intended to be done; and
  - mistakes – doing the wrong thing believing it to be right.

- violations – any deliberate deviations from rules, procedures or instructions drawn up for health and safety. Violations are also divided into three categories:
  - routine violations – breaking the rule or procedure as a normal way of working within the company;
  - situational violations – breaking the rule due to pressures from the job such as being under time pressure, or the right equipment not being available; and
  - exceptional violations – happens very rarely and only when something wrong has happened. Breaking rules believing benefits outweigh risks.

- ✍ The potential for human failure was assessed by analysing all human factors that may contribute to such failures. The human factors were analysed during industrial interviews, mine visits and the risk assessment workshop, and can also be thought of as shortcomings of control measures identified to reduce risks related to scraper winch systems. A general analysis of human failure was conducted. There was no attempt during the analysis to breakdown human failure according to consequence (active or latent) or type (errors or violations).

Appendix 6: Legal Requirements in Scraper Winch Systems

Chapter 19 of the Minerals Act of 1991 of South Africa contains Regulations specifically applicable to scraper winch systems, and Table A5:1 contains a summary of these Regulations and comments on their clarity and application where necessary. Table A5:2 contains a summary of Regulations that may also be interpreted as being applicable to scraper winch systems.

Table A6:1 Regulations Applicable to Scraper Winch Systems

Regulation	Synopsis	Comment
19.1	No person shall operate or cause or permit any other person to operate a scraper winch unless appointed to do so by the Manager or Mine Overseer.	
19.2.1	Subject to 19.2.2 every scraper winch installation shall be provided with an effective signalling system whereby distinct signals can be given from any point along the path traversed by the scraper shovel *(scoop)* to the winch driver.	This is a one-way communication in which only the driver receives the signal but does not send any signal back to acknowledge having received the sent signal.
19.2.2	Any accessible remote controlled scraper installation where the whole path of the scraper is not visible to the winch operator/driver shall have a distinct audible signal to warn persons of the intention to start the winch.	
19.3.1	No person other than a person instructed in the safe and proper use of the signalling arrangement shall give any signal other than the signal to stop the scraper winch.	
19.3.2	After stopping the winch, the winch operator shall only restart it after receiving a distinct signal to so.	At this stage, it is not clear whether the signal should come from the person instructed in the safe and proper use of the signalling arrangement or whoever gave a signal to stop the

		winch in the first place.
19.3.3	The winch start-up procedure involves moving of scraper ropes gently.	In very long and winding gullies, the effectiveness of this procedure is questionable. In the presence of many persons along the gully, the movement of ropes can be interpreted as being caused by the movement of persons and not as a warning of the intention to start the scraper winch.
19.3.4	Only persons mentioned in 19.3.1 can give signals to the operator to restart the scraper winch.	The need to cross-reference may lead to confusion, and this Regulation should have been placed immediately after 19.3.1 or combined with it.
19.4	Effective arrangements shall be made to avoid fouling of ropes or scoops where two or more systems operate in conjunction.	
19.5	Installation of sheave wheels and snatchblocks shall be in accordance with the standard approved by the engineer or a competent person appointed in terms of Regulation 2.13.2.	Minimum prescriptive guidelines should be issued describing what is proper and not.

Table A6:2: Other Regulations Applicable to Scraper Winch Systems

Regulation	Synopsis
2.13.12	Any person may be permitted by the Principal Inspector of Mines, subject to such conditions as he may specify, to exercise control over ? the proper operation and running of machinery ? the erection, moving or removal of machinery not used for the conveyance of persons
7.1	Making and maintaining workings safe
8.1.2	Protecting workers against falls of ground or other dangers
11.3.8	All machinery shall be so constructed, installed, operated and maintained as to prevent as far as practicable, dangerous heating
15.3.1	Machinery to be illuminated (repealed)
20.3.1	Dangerous places such as tips to be fenced off effectively
20.4	Loose clothing not permitted in close proximity to moving machinery
20.5	All exposed moving machinery to be fenced off efficiently
20.6	Repairing and oiling of machinery in motion by a competent person
20.7.3	Machinery to be set in motion after taking reasonable precautions
20.8	Precautions for the safety of persons using machinery
20.9.1	Condition of safety appliances to be maintained in good working order
20.9.2	Substandard or dangerous machinery not to be used until ensured safe