Safety in Mines Research Advisory Committee

Final Report

RISK ANALYSIS AND ASSESSMENT OF VERTICAL AND INCLINE SMALL WINDER SYSTEMS AND PERIPHERAL ACTIVITIES

P S Moss, C F Talbot, P J Foster, A M Rushworth.

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Executive Summary

This research uses a risk analysis approach to study the design, installation, operation, maintenance, inspection and testing of small winder systems and peripheral activities. A review of the SAMRASS database was used as a first step in identifying the small winder applications that are most prone to accidents, and to identify the most significant hazards and risks related to them. Subsequent investigations on selected mines using a risk assessment based process, in line with the requirements of the Mine Health and Safety Act, provided an objective, well understood means of investigating limitations in equipment specifications and current operational and maintenance procedures. The risk assessment process was augmented by site observation of work practices to identify human factors that may contribute to accident risk.

The resultant data were then used to identify generic hazards and the factors most likely to significantly influence the reliability of those control measures being used to mitigate health and safety risks. These findings were then discussed with suppliers of small winders and associated equipment to the mining industry. The results of these discussions, together with the earlier findings and a review of relevant regulatory topics, were presented to several groups of mine users to obtain their comment and input.

Significant variation in terms of the design, operation and maintenance standards applied to small winders across mines were identified. Those installations licensed for man winding tended to be well designed and maintained; however standards differ greatly on the many small unlicensed material winders. In part this is due to a lack of clarity in the regulatory requirements.

The risk assessments facilitated by the project identified a wide range of problems and limitations that impact on the effectiveness and reliability of the measures currently being used to mitigate health and safety risks. These included limitations in: operating procedures; inspections, testing and maintenance regimes; physical safety barriers; and lock-bell systems.

It is concluded that risk assessment conducted at mines, as required by the Mine Health and Safety Act, has the potential to identify many of the significant hazards and control limitations associated with small winder systems and result in significant reduction of the associated risks. To support this improvement process it is recommended that consideration be given to:

- introducing a Safety Standard for small winder operations which would identify minimum requirements and act as a technical guideline for users; and
- encouraging mines to conduct risk assessments for all their small winder operations as a matter of priority. A checklist has been produced to assist mines in identifying potential control limitations when assessing risks.

It is also recommended that the findings of risk assessments should be used as an integral part of the training process, and that relevant parts of an existing rope inspection Standard should be used for certification of persons responsible for undertaking visual rope examinations.

Acknowledgements

We record with appreciation the assistance and hospitality that we received from the various mines who participated in the risk assessment work, and for the attendance and enthusiasm of mine officials at the user workshop discussions. The interest shown at all stages of the project was very encouraging.

Also, we would like to thank the following people and organisations who contributed to the project:

- Mr PS Laubscher for his very useful input on technical topics and review of the regulatory aspects;
- the various original equipment manufacturers who gave valuable input;
- staff of the Department of Minerals and Energy;
- staff of the Anglogold Training and Development Services, Free State Operations; and
- Mr H Nicholas for his assistance in researching the SAMRASS database.

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Glossary of terminology

Winder

On mines, winding plant is referred to variously as being a “winder”, “hoist” or “winch”. For the purposes of clarity, the term “winder” has been used throughout this report.

Small winder

A winding plant driven by a motor developing not more than 250 kilowatt, and used for man, material or rock winding (or any combination of these) in a vertical or incline shaft.

The project scope excluded:

- monorails;
- chairlifts;
- lifting machines;
- continuous haulages;
- elevators;
- scraper winches;
- air driven winches; and
- small handling winches on surface.

Note that this project definition is broader in scope than the definition of “small winding plant” contained in Regulation 16.94 of the Regulations to the Minerals Act, which effectively excludes the man winding application. Man winding was included in this project at the specific request of SIMRAC.

Small winding plant

Used in the strictly legal sense as defined in Regulation 16.94.

Incline shaft

Mines refer to a shaft on an inclined plane as an “incline” or “decline”, usually depending on the mining method used. For the purposes of clarity, the term “incline” has been used throughout this report.

Peripheral activities

Those facilities and operations within and around the shaft which are external to the actual winder but form part of the overall operation of the shaft system, for example:

- operations within and maintenance of the shaft;
- station operations; and
- station layout.

Safety drop rail

A single steel rail or joist supported from the hanging wall by a hinge its top end and resting at an angle on the footwall, so forming a safety barrier. It can be manually raised and lowered in a vertical plane using a rope and counterweight mechanism, to allow the passage of cars when required.

It is extensively used to prevent the inadvertent entry of material cars from stations into incline shafts, and to derail a runaway car so preventing it from entering a station area.

Safety drop set

A sturdy steel frame supported from the hanging wall by a substantial hinge its top end and resting at an angle on the footwall of an incline shaft, so forming a safety barrier. It can be manually raised and lowered in a vertical plane using a rope and counterweight mechanism, to allow the passage of cars when required.

It is used in an incline shaft as a safety barrier to stop a runaway car proceeding further down the shaft.

Station drop set

A substantial steel frame that is hinged from the footwall of an incline shaft station, and which can be raised out of or lowered into the shaft by means of a small winch. Steel rails, which match those in the incline shaft, are fitted to the top of the set, so permitting a car to be moved from the incline shaft onto the station when the set is lowered.

The above three definitions relating to drop rails and drop set have been used consistently throughout the report. Whilst it is recognised that these definitions may not be universally accepted throughout the industry, they are based on the descriptions most commonly used by the mines.

1. Introduction

There are several thousand small winder installations in South African mines. They are used for many different applications including the hoisting of men, materials or minerals in either vertical or incline shafts. They have different usage profiles ranging from heavy to infrequent use, and are often located in distant parts of the mine in damp, hot environments. Concern has been expressed regarding the high accident rate associated with the operation and maintenance of these installations and the range of peripheral activities associated with small winder operations. In particular, the raising and lowering of material via inclined shafts, either as a routine operation for moving mining supplies to the stoping areas or as a “special” movement of heavy equipment such as locomotives, is seen as a particularly hazardous operation.

Over the years moves have been made to improve the operational safety of these installations. Mine management has, for example, introduced training schemes, provided new designs of equipment and installed additional safety devices. The Inspectorate has assisted the industry with advice and guidance and the interpretation of legal requirements. The introduction of the risk assessment process by the Mine Health and Safety Act has involved workers directly in the review of designs and operational activities. However, despite these initiatives, accidents and incidents associated with the use of small winders remains an area of major concern to the industry.

The requirements for the licensing, operation and inspection of winding plant are covered in Chapter 16 of the Regulations to the Minerals Act. This Chapter is however concerned primarily with the requirements for main winding plant rather than small winders. Consequently the requirements for small winding plant are not as onerous as those for main winding plant and in several respects fail to provide clear standards or criteria against which any particular installation can be assessed. This is understandable since there are many different applications for small winders and the relative risks to health and safety will vary considerably across these applications. This situation however, creates uncertainty and a potential conflict as the industry’s requirements for improved standards of safety have to be subjectively weighed against economic pressures and operational practicalities. There is often a tendency to add more controls to improve safety, but such moves can be counter-productive if they are not cost effective and carefully considered as part of an overall plan to effectively manage the relative levels of risk encountered throughout industry.

Past research experience has shown that an analysis of accident and incident reports can be valuable in providing an indication of total risk to the industry and the range of potential hazards existing within broad operational areas. However, such an analysis is likely to have limited value in identifying hazard control failures, which are the true underlying causes of accidents. Furthermore, an approach based primarily on historical accident and incident data is reactive rather than pre-emptive and will not necessarily reflect current practices, risks and control measures. In order, therefore, to identify the critical problem areas associated with the design, maintenance and operation of small winders there is a need to employ a targeted and detailed risk analysis based methodology.

Traditionally, the primary focus for improving mining health and safety has centred on engineering and technical developments. This approach, although extremely successful in the past, is now providing diminishing returns. It is becoming increasingly recognised that human behaviour holds the key to further improvement. Peake and Ritchie, for example, in SIMRAC project OTH 003 concluded that “ while failures of a mechanical or environmental nature are major contributors to an accident, the human factor, which is the least understood and the least predictable, has an influence on the greatest number of accidents”. Similarly, in studies to identify the causes of transport and tramming accidents, SIMRAC projects OTH 202 and COL 506 identified a whole series of accident likely situations where the reduction in accident potential required a greater understanding of the factors which create error potential. International research has shown that wherever people are involved, whether as designers, operators, maintenance staff or management, individual performance and human reliability significantly influences the overall safety and efficiency of all mining operations. It is important, therefore, that any investigation of small winders incorporating an analysis and assessment of risk should also include a review of the potential for human error.

2. Methodology

Accident and incident information held on the SAMRASS database that may potentially have been related to small winder incidents on gold and platinum mines for the period 1988 to 1999 was collated and analysed to:

◊ provide an indication of the range of hazards and causal factors most likely to predispose accidents, and hence contribute to risk, that should be addressed by the project; and

◊ assist in the selection of mine sites to include in the project studies.

To enable a systematic study of the critical problem areas associated with the design, maintenance and safe operation of small winders, the following three key procedures were used:

1. Engineering Risk Assessment
2. Health and Safety Risk Assessment
3. Human Error Assessment

The principal features of these procedures are defined below:

2.1. Engineering Risk Assessment

To assess the engineering risks related to the small winders studied, an approach based on Failure Mode and Effects Analysis (FMEA) was used. FMEA is a form of qualitative hazard analysis which aims to identify the nature of failures which can occur in a system, machine, or equipment. Subsystems or components are examined in turn, considering for each the full range of possible failure types, and the effect on the system of each type of failure.

In simple terms it is a process that has been developed to answer the questions ‘how can the unit fail?’ and ‘what happens then?’

The steps employed to conduct the assessment were:

1. Define the scope of the study This was achieved by identifying and listing the main components of the winder system which were to be included in the analysis.

2. Decide the level of analysis In this broad study the main components of the winder system as identified above were used as the elements for analysis.

3. Identify all the potential failure modes A ‘failure mode’ is best described as the way in which a component fails. For each component identified in the scope definition the most significant failure modes were identified and listed.

For individual mechanical components these could include:

- mechanical breakage
- excessive wear
- corrosion
- etc.

For electrical components the failure modes could also include:

- open circuit
- short circuit
- etc.

4. Estimate the likelihood of failure For each failure mode a subjective estimation was made on the likelihood of such a failure using the following scale:

Likelihood of failure		
1	Likely	Once a year or more often
2	Occasionally	Once every 5 years or more often
3	Rarely	Once every 20 years or more often
4	Extremely rarely	Once every 40 years or more often

5. Identify any failure detection methods For each of the failure modes any methods of detecting that failure, either by active or passive means, were identified. Failure detection methods could include:

- Overspeed tripping devices
- Overwind detectors

6. Identify all control measures in place For each of the failure modes any control measures that were in place were identified. In the context of this engineering risk assessment control measures are defined as 'anything that is done to reduce the likelihood of a component failure'. These control measures could include rules and procedures, inspections and maintenance.

7. Assess the effectiveness of the control measures identified In order to make an assessment of the risk, it was necessary to determine how well the control measures work by looking at how effective they were in practice. Any factors that influenced the effectiveness of control measures were identified as control 'shortcomings'.

8. Identify any significant potential hazards For each failure mode identified, the effects of the failure were considered for any possible health and safety implications. From this the associated significant potential hazards were identified.

9. Estimate the severity of each hazard For each significant potential hazard that was identified, the most likely severity of the hazard occurring was determined based on the following scale:

Most likely severity	
1	Lost Time Injury
2	Permanent Disability
3	Fatality
4	Multiple Fatalities

10. Obtain a risk rating using the risk matrix The estimates of likelihood and severity were combined using the risk matrix shown below to give a risk rating for each significant potential hazard identified.

Most likely severity				
Lost Time Injury	**1**	**2**	**4**	**7**
Permanent Disability	**3**	**5**	**8**	**11**
Fatality	**6**	**9**	**12**	**14**
Multiple Fatalities	**10**	**13**	**15**	**16**
Likelihood	Once in 40 Years	Once in 20 years	Once in 5 years	Once a Year

Format for Engineering Risk Assessment

The format of the pro-forma that was used to document engineering risk assessments is shown below.

Component	Failure mode	L	Failure detection methods	Control measures	Short-comings	Potential hazards	S	R
Note (1)	Note (3)	(4)	Note (5)	Note (6)	Note (7)	Note (8)	(9)	(10)

2.2. Health & Safety Risk Assessment

Sections 11 and 21 of the Mine Health and Safety Act place an unequivocal responsibility on manufacturers and suppliers and on employers to ensure the health and safety of employees at mines through the process of risk assessment. Implicit within these responsibilities is the requirement to identify any significant risks that may arise from any ergonomic (or human factors) limitations. It was considered logical therefore to adopt such a process to identify the critical problem areas associated with the design, maintenance and safe operation of small winders. However, given that the Act does not specify a procedure for risk assessment, it was necessary to identify a straight forward rational procedure that:

- took cognisance of the findings of risk assessments already undertaken by the participating mines;

- conformed to the principles given in the Practical Guide to the Risk Assessment Process (1997); and

- facilitated a consideration of those factors related to human performance and the potential impact of human factors on the overall reliability and performance of system components.

The process employed during the project is outlined below:

1. Identifying and scoping the boundaries of the assessment

The risk assessment procedure was designed to examine vertical and incline small winder systems and their peripheral activities. Peripheral activities included those facilities within and around the shaft which are external to the actual winder but form part of the overall operation of the shaft system. A location-based approach was followed when carrying out the assessments. This was achieved by identifying and listing the main locations (and activities carried out therein) within each winder system examined for independent assessment. These locations included, for example, hoist rooms, headgear, bank, shaft, shaft stations etc.

2. Identifying hazards

The Act defines "hazard" as *a source of or exposure to damage*. Hazard means anything with the potential to cause harm. When carrying out risk assessment the potential hazards were identified by a risk assessment team from the mine by:

- systematically examining each task and activity carried out in each location identified in 1; and

- using their own experience of the operations being addressed.

3. Identifying controls and control shortcomings

Controls are any measures designed to reduce the likelihood of a hazard occurring, or the severity of harm that may arise if it does. This part of the process involves identifying:

- all the control measures that are in place that reduce the risk of the hazard occurring; and

- any "control shortcomings" that exist and reduce the effectiveness of the controls.

As with hazard identification, current control measures and shortcomings were identified systematically by the mine risk assessment team using their experience of the operations being assessed.

Consideration of any ergonomic or human factors limitations were facilitated at this point in the process by members of the project team who had considerable experience in this field.

4. Assessing the risk

In a risk assessment it is a requirement to do all that is *'reasonably practicable'* to eliminate or reduce the risk. At this stage in the process it was necessary to ask the question "Can we do any more that is reasonably practicable to reduce the risk?"

- If the answer to the question is "yes", there is a necessity to improve the controls; and
- if the answer is "no", then the risk can be considered to be as low as is reasonably practicable i.e. "ALARP", and no further action is necessary.

In deciding what is reasonably practical, it is necessary to consider:

- how bad the hazards and risks are;
- how much is known about them and how to control them;
- what ways are available to control the risk; and
- what will they cost in comparison to the likely benefits.

5. Improving controls

Where it is necessary to improve controls, this can be achieved by either introducing new control measures or by increasing the reliability of the existing control measures. When considering what remedial actions are to be implemented, the Mine Health and Safety Act requires consideration to be given to:

- eliminating any recorded risk;
- controlling the risk at source through engineering controls;
- minimising the risk through operational controls; and
- providing personal protective equipment and monitoring.

6. Estimating risk

Where it is found necessary to identify remedial actions to eliminate or reduce the risk, then an estimate of risk should be made. These estimates can be used to allocate priorities for implementing remedial actions. The risk matrix introduced in Section 2.1 Engineering Risk Assessment can be used to estimate the level of risk. The matrix is repeated below. Here again, the estimates of likelihood and severity are combined using the risk matrix to give a risk rating for each significant potential hazard identified.

Most likely severity				
Lost Time Injury	**1**	**2**	**4**	**7**
Permanent Disability	**3**	**5**	**8**	**11**
Fatality	**6**	**9**	**12**	**14**
Multiple Fatalities	**10**	**13**	**15**	**16**
Likelihood	Once in 40 Years	Once in 20 years	Once in 5 years	Once a Year

7. Recording the assessment

The format of the pro-forma that was used to document the health and safety risk assessments is shown below:

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Note 2	**Note 3**	**Note 3**	**Note 4**	**Note 5**

2.3. Human error assessment

Research into the root causes of mining accidents has repeatedly shown that between 70% and 90% of them can be attributed to human error. The majority of these human errors tend to occur at the man-machine interface. As a result, ergonomics or human factors play a major role in determining the likelihood of these human error related accidents occurring. Human error assessment was undertaken using elements of the IMC behavioural safety system known as BeSafe. The BeSafe System incorporates an investigative technique referred to as the Potential Human Error Audit which provides a method of examining human error potential through the identification of *Active Failures*. The technique was used successfully in SIMRAC projects OTH 202 and COL 506 to investigate the causes of transport and tramming accidents. The technique was adapted to investigate the potential for human error in the design and operation of small winder installation. The technique used is detailed in Appendix 2.

2.4. Integrated approach to mine studies

An integrated assessment methodology combining the essential elements of all three procedures described above was required to ensure an efficient and effective approach to mine based studies for the following reasons:

- it provided a more rapid and extensive elicitation of material from mine staff;
- it provided the project with a rational approach for dealing with problems of an interactive nature; and
- it enabled a unified summary to be produced of the critical issues that need to be addressed by the principal stakeholders.

This integrated approach involved the following activities at each study site:

◊ an examination of equipment specifications, maintenance schedules and testing protocols;

◊ a review of the mine's operating rules and procedures and training material;

◊ discussions with the mine's safety and/or training staff and engineering staff responsible for small winders;

◊ an examination and assessment of the installation and the standards of maintenance provided;

◊ facilitation of a subjective health and safety risk assessments of both routine operational use and breakdown maintenance activities using a team of mine staff coached in the methodologies outlined above;

◊ elicitation of suggestions for additional controls and/or improvements to current risk control measures from mine staff; and

◊ preparation of a confidential report containing the results of the risk assessment exercise and the recommendations that arise from it.

Whilst facilitating the subjective risk assessment the project team discussed the potential human errors and engineering limitations that had been identified during the earlier examination and assessment of the installation. As a result, the assessments of risks obtained during each mine study take cognisance of the control limitation identified at each site.

The findings from all the mine risk analysis studies were then collated and analysed to identify examples of existing good practice and control shortcomings. These were then used to produce generically applicable recommendations for improvements in areas where it is likely to be reasonably practicable to achieve further reductions in risk.

2.5. Discussion with original equipment manufacturers and consultation at User workshops

Discussions were held with original equipment manufacturers and consultants from the industry to review the findings of the research and obtain input.

User workshops were also arranged so that the findings of the mine risk analysis studies could be reviewed and commented on by experienced mine officials who were involved with the maintenance and operation of small winders.

3. Results

The results presented below are those that are most likely to be generically applicable to small winders. Additional and/or more detailed results obtained during the project can be found in the following appendices:

Appendix 3	Comments from the User Workshops
Appendix 4	OEM discussions
Appendix 5	Engineering risk assessment findings
Appendix 6	Mine risk assessments

3.1. Analysis of accident and incident records

An analysis of accident and incident information held on the SAMRASS data base was undertaken with a view to identifying the most significant risks and to assist in the selection of mine sites to include in the project studies. Within the SAMRASS accident recording system there are no codes that uniquely identify small winder incidents and hence it was necessary to take an iterative approach to isolating and analysing those recorded accidents that would be most relevant to the project. The approach taken and the results obtained are described below.

3.1.1 Selection of accident records

Initially accidents classification codes were used to select both casualty and non-casualty accidents from the SAMRASS database that may potentially have been related to small winders incidents on gold and platinum mines for the ten year period 1988 to 1999. This resulted in 2895 accident records being retrieved from the SAMRAS database.

Each of the resultant records were then examined in an attempt to determine, from the information they contained, whether or not they related to small winder incidence. From the available information 439 of these records were clearly related to large licensed winders and hence removed from the analysis set. However of the remaining 2456 accidents only 9 could be positively identified as being directly related to small winder incidents from the information provided. Given that so few reported accidents and incidents could be positively attributed to small winder incidents from the principal data fields, any further assumptions made would need to be based on the brief descriptions of accidents included in the database. These accident descriptions are only available for accidents recorded since January 1995. Excluding incidents prior to this date reduced the potentially usable data set to 478 records.

Although the brief accident/incident descriptions provided a little more insight into the accident/incident, again they were found to be of little or no value in distinguishing between small and large (licensed) winder incidents. Given the inherent uncertainties that remained within this subset, it was not possible to extract any reliable indications of risk, and any further interpretation of the data set would need to clearly acknowledge that it represented both large and small winder incidents. Even with these potential limitations, it was felt that the severity and causal profile of the incidents within the selected data-set would provide a good indication of the range of hazards and causal factors most likely to pre-dispose accidents, and hence contribute to risk, that should be addressed by the project.

A unique number identifies each reported incident in the SAMRASS database, and for accidents where more than one person is killed or injured the database contains a separate record for each of the individuals concerned. Hence two statistics can be derived, the number of incidents, and the number of people involved. The distribution of these statistics in accordance with the type/severity of the incident is shown below in *Table 3.1*.

Table 3.1 Type/severity of incidents related to Winders for the period 1995 to 1999

Severity of Accident	Number of Incidents	Number of Persons
MULTIPLE FATALITIES	1	2
SINGLE FATALITY	19	19
MULTIPLE INJURY	4	11
SINGLE INJURY	149	149
NON-CASUALTY	296	-
TOTAL	469	181

Table 3.2 shows the distribution of reported accident causes found within the selected data set. This table demonstrates that there are some differences in the frequency with which accidents causes are attributed to casualty and non-casualty incidents. For example, “inadequate preventive maintenance” is quoted as the cause of a higher proportion of non-casualty indents than for accidents involving reportable casualties. Conversely, “lack of caution/alertness” and “failure to comply with instructions “ were attributed to a higher proportions of reportable casualty accidents. These relatively small variations are likely to arise primarily as a result of the type of incident being reported. Given the need to address both accidents and incidents the accidents causes listed in *Table 3.2* were used to define the range of hazard control limitations that would be investigated during the remainder of the project.

Table 3.2 Causes of accidents and incidents potentially related to Small Winders for the period 1995 to 1999

Cause of Accident	NON-CASUALTY	SINGLE INJURY	MULTIPLE INJURY	SINGLE FATAL	MULTIPLE FATAL
Failure to comply with recognised good practice/standards	104	83		12	
Inadequate examination/inspection/test	58	6	2		
Inadequate preventive maintenance	45	1		1	
Use of unsuitable/defective equipment/material	18	3		1	
Lack of caution/alertness	16	31			
Lack of clearance(obstruction)	14	2	2		
Failure to comply with instructions	13	8	5	4	
Failure to use safety or protective devices/equipment	10	3		1	
Lack of (or unsuitable) system(s)/facilities	10	2			
Rendering safety device ineffective	3				
Failure to supply safety or protective devices/equipment	2	4			

Cause of Accident	NON-CASUALTY	SINGLE INJURY	MULTIPLE INJURY	SINGLE FATAL	MULTIPLE FATAL
Inadequate supervision/discipline	2	3			2
Inadequate (lack of) fencing/guarding	1	1			
Failure to supply proper tools/equipment		1	2		
Lack of (or inadequate) standards/procedures		1			
Lack of adequate/suitable training/instruction				1	

The principal causes of "non-casualty" incidents are shown graphically in *Figure 3.1* and for "single injury" incidents in *Figure 3.2*.

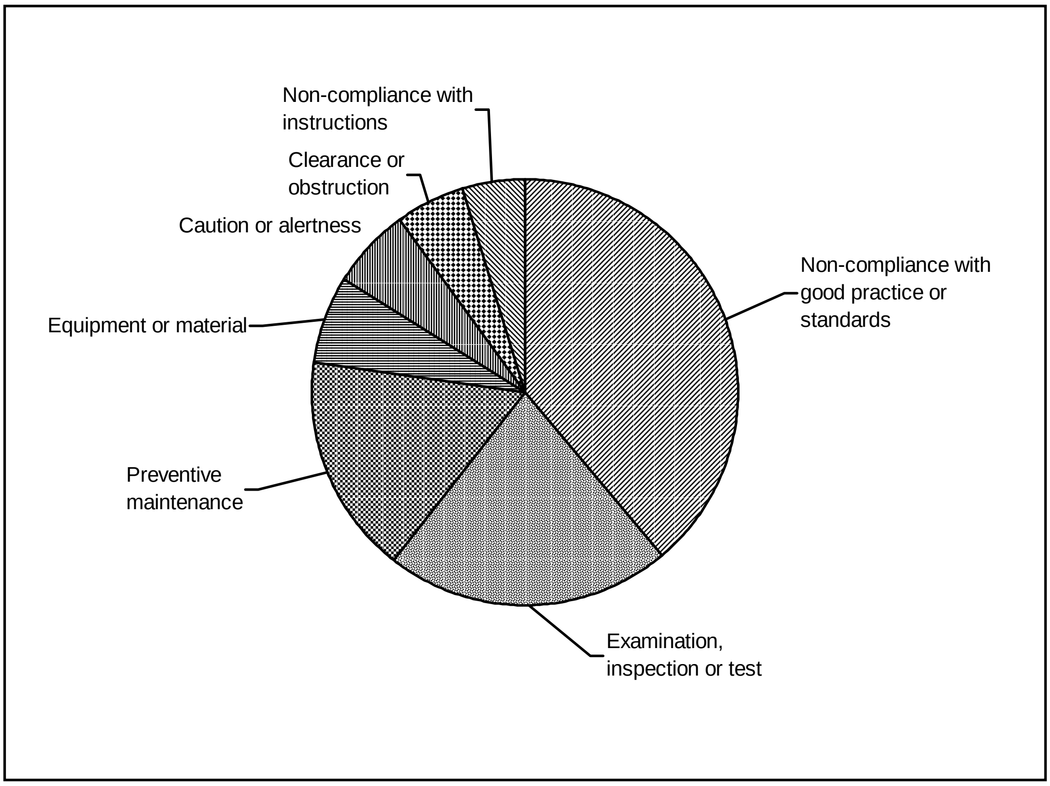


Figure 3.1 Causes of non-casualty incidents

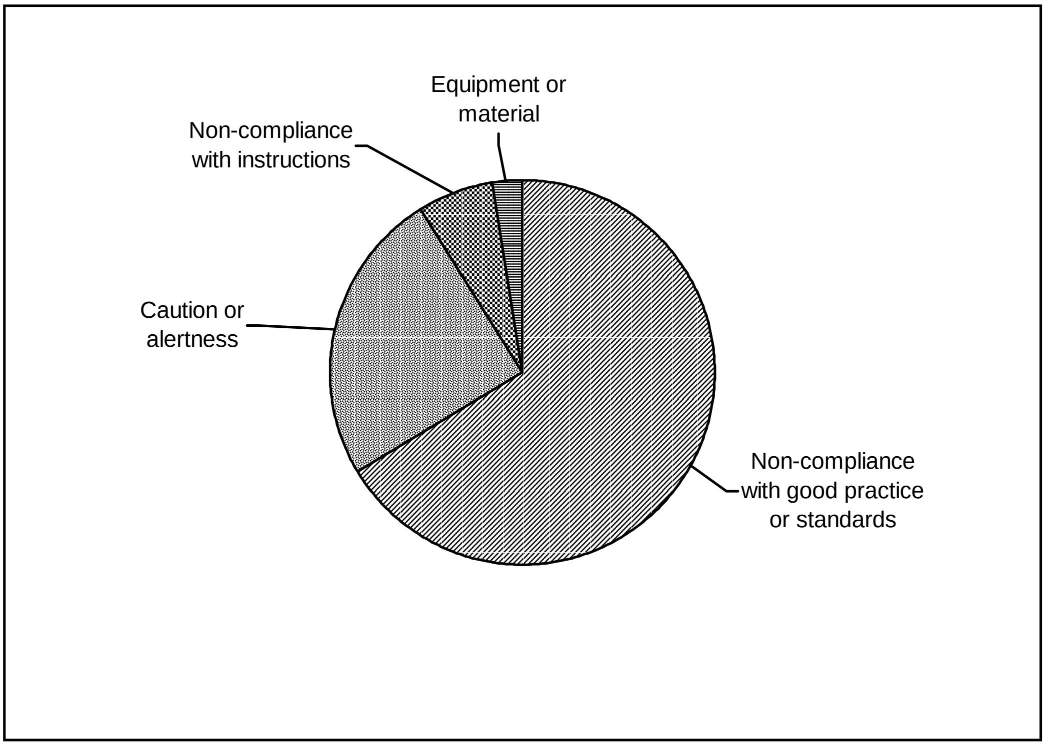


Figure 3.2 Causes of single casualty accidents

The non-casualty incident figures reflected in *Figure 3.1* will be related primarily to large winders although a small proportion may represent small winders operating in the same shaft as a large licensed winder, when they must be licensed and are subject to the same reporting requirements.

It is likely that the causal factors shown in *Figure 3.1* also represent the main issues that require further investigation to help reduce the risks arising from small winders. Hence, using this information as a guide, it is proposed that the main focus of the project will be on those factors likely to influence:

- compliance with rules, procedures and good working practices;
- the effectiveness of preventive maintenance procedures and the reliability with which they are carried out; and
- the ability of current inspection/testing practices and pre-use checks to proactively identify potential hazards.

The casualty figures reflected in Figure 3.2 are likely to contain a higher proportion of small winder accidents and reinforce the need for a particular emphasis to be placed on behavioural safety and those factors that influence human reliability. Hence, although the project will address engineering issues such as layout and maintenance standards directly, the primary focus will be on reducing the potential for human error and non-compliance.

3.1.2 Small winders: single fatality accidents

The following single fatality accidents were positively identified as being related to small winder operations:

1. A single-drum winder operator was fatally injured when he was struck by a material car at the bottom of an inclined shaft.

While being transported up the inclined shaft, two full material cars became disconnected from the pilot car and ran back down the inclined shaft. The inquiry revealed that in contravention with the operating instructions, two material cars instead of one were connected to the conveyance.

The two material cars were connected to each other and to the pilot car using chain, as the buffers were in such poor condition that the normal couplings and pins could not be used. In addition, the safety sling was also connected by means of a chain and bolts. On the way up, the chains failed and the cars ran down to strike the now-deceased who was not in a position of safety.

2. A contractor fitter was fatally injured when he was struck by an empty runaway material car.

The accident occurred on a station of an inclined shaft when two empty material cars being hoisted up the inclined shaft behind the pilot car, broke loose and ran down the inclined shaft and around the rail-switch leading onto the station.

The cars had been coupled behind the pilot car by the now-deceased without making use of the safety sling. The inquiry revealed that it is most likely that pigtail eye-bolts and not hopper pins were used to secure the material cars.

The inquiry further revealed that a drop-rail safety device had been rendered ineffective by being tied up in the open position.

The now-deceased was not appointed to give shaft signals for the hoisting of material cars and had not been trained in the duties of an onsetter.

3. A single-drum winder operator was fatally injured when he was struck by a run-away material car on the lower level of an inclined shaft when the winch rope broke.

Shortly before the accident occurred, a bogey car and a loaded material car were connected to the winding rope to be lowered to the bottom level. Sufficient slack rope was than paid out to enable the cars to be pushed over the brow of the incline. However, it appears that too much slack rope was paid out, because the cars went down the incline and caused the rope to break, resulting in the accident.

The enquiry revealed that all the hazards associated with the operation had not been identified, the risks were not assessed nor had effective preventative instructions been given in which the operators could have been trained. In addition, the incline shaft safety devices had been rendered inoperable.

4. A boilermaker working at the bottom station of a material incline was killed when he was struck by a runaway locomotive.

The locomotive was being slung up an incline shaft. When the locomotive was halfway up the incline, the winding rope snapped, causing the locomotive to run away down the inclined shaft and strike a boilermaker busy with installation work at the bottom. According to evidence the safety rope was attached to a thin sling between the locomotive and the pilot car; when the winding rope snapped and the locomotive ran away, the thin sling used to connect the safety rope also failed.

A safety drop rail in the incline also broke when struck by the runaway locomotive. RSJ stop blocks at the bottom of the shaft were not in place at the time of the accident.

The main cause of the accident was the deterioration of the strength of the winding rope due to excessive abrasive wear.

5. A shift boss was killed in an incline shaft when the skip he was riding in derailed and he was flung out.

6. A workman was killed when, contrary to procedures and a warning, he travelled in a small skip in an incline shaft and was crushed against the hanging wall.

3.2. Selection of study sites

Mine sites for the risk assessment studies were chosen to give as wide a spread as possible of activities, type of installation, type and size of mine, and geographical location. This would help to ensure that the sample was sufficiently varied and as representative of the many different installations as possible, which was important to provide proper project outputs and obtain "buy-in" from the eventual end users. Cognisance was also taken of the comments from the GAPEAG Committee, mines, the Inspectorate and OEMs in deciding the mine selection.

The various selection criteria employed by the Project and the profile of the mines finally selected for study are shown below:

Type of mine

• gold • platinum	• both mine types were covered since the Project was initiated by the GAP Committees.

Size of mine

• large • small	• larger mines should have more formal procedures and management structures than smaller operations

No formal cutoff point was defined between "large" or "small". For the purposes of the project, "large" mines were selected as being (sometimes historically) members of a larger Mining House, with a tradition of administrative and technical control from a central point external to the mine. "Small" mines were those where the individual mine ran its own affairs, and were smaller scale operations than the "large" mines.

Geographical location

• to cover the major gold and platinum mining locations in SA	• it was considered important to select a representative spread of geographical areas in order to obtain a wide span of inputs and to facilitate user "buy-in" to the project

The locations of the Central Rand (East and West), Far West Rand (Carletonville/Klerksdorp) and the Free State Goldfields were considered as the most active and likely to provide cost-effective input to the project.

Installation type

• small winder located on surface • small winder located underground	• it will be apparent that higher standards of operation and maintenance can be expected on installations located on surface as compared to underground, and it was important to include both of these winder locations in the research in order to provide a complete picture

• working in a vertical shaft • working in an incline shaft	• installations in vertical shafts, often associated even indirectly with licensed winding plant, could be expected to have higher standards than small winders on incline shafts, which are often situated in remote areas of the mine and operated/maintained by production orientated personnel

Small winder duty

• man winding	• small winders for man winding would need to be licensed and would therefore provide a useful benchmark against which other installations could be assessed
• rock	• rock winder installations have specific hazards related to their materials handling issues
• material	• this represents the normal duty for small winders and also appeared to have the highest risk rating
• multi use	• this could potentially have a high risk rating due to differing engineering and procedural requirements for the different duties.

Operation

• routine activities	routine activities represent the largest exposure time to hazards and are thus of fundamental importance to any risk assessment study
• movement of heavy material	since these are usually carried out by staff other than those in charge of routine operations, the overlap of areas of responsibility has the potential to increase the risk
• shaft sinking	well known in the mining industry as a potentially hazardous operation, this topic was included at the particular request of the GAPEAG Committee.

Table 3.3 Final selection of mines

Type & size of mine	Location	Installation type	Small winder duty	Operation
Gold, large	Free State	• underground, incline	• material	• routine • heavy material
Gold, large	West Rand	• underground, vertical	• man	• shaft sinking (sliping operation)
Platinum, large	Rustenburg	• underground, incline	• man, material, rock	• routine
Platinum, large	Rustenburg	• surface incline • surface incline	• rock • material	• routine • routine
Gold, small	East Rand	• surface vertical	• man, rock, material	• routine
Gold, small	West Rand	• surface incline	• material	• routine
Gold, large	Far West Rand	• underground incline	• material	• routine • heavy material

3.3. Regulatory aspects

A review was undertaken of the Regulations that are provided under the Mine Health and Safety Act and the Minerals Act for the control of activities related to small winders. This provided essential background for the site investigations and subsequent discussions with interested parties.

As far as this Report is concerned, the legal framework pertaining to mine activities consists of two Acts and their associated Regulations:

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

The MHSA was promulgated early in 1996; prior to that date the Regulations to the Minerals Act were used to define the requirements for mining operations. It is intended that the new Regulations to the MHSA will replace those of the Minerals Act, but drafting of these is still in progress. It is noted that revisions to the Regulations related to the Minerals Act are being promulgated under the authority of the MHSA.

In view of the fact that the only substantive technical Regulations are those previously promulgated under the Minerals Act, and that mining industry personnel are familiar with this terminology, this report will refer to the current Regulations as being part of the Minerals Act.

The requirements for winding plant are contained in Chapter 16 of the Regulations; most of this Chapter is concerned with winders licensed under Regulation 16.2.1, being those used for man winding.

For the purpose of this report:

- the term " small winder" is used where the driving motor does not exceed 250kW, and includes licenced and unlicenced units;

- the term "small winding plant" is used as per the definition in Regulation 16.94 for unlicenced winders where the driving motor does not exceed 250kW.

Table 3.4 summarises the current Regulations relating to small winding plants, and contains comments on their clarity and application. *Table 3.5* lists the Regulations specifically excluded from applicability to small winding plants by Regulation 16.95.1

Table 3.4 Mining Regulations applicable to small winding plants

Regulation	Synopsis	Comment
16.94	Small winding plant defined as: having a drive motor of not more than 250 kW; not used for the conveyance of persons (other than shaft examination & repair); and not working in the same shaft as a conveyance of a licensed winder.	prescribed permit not required
16.95.1	gives a list of Regulations not applicable to small winding plant as per Regulation 16.94 (see Table 3.5).	the need to cross-reference back to other Regulations causes confusion there are some anomalies eg it appears sensible that the following excluded Regulations should apply, in principle, to small winding plant: ▪ 16.5.1: winder can be readily slowed and stopped, and can be restarted immediately in either direction ▪ 16.7: depth indicator to be fitted
	the Manager shall appoint any competent person to carry out the duties and examinations prescribed in Regulation 16.74 (ie a <u>daily</u> examination of the listed components as per 16.74.1 and a <u>weekly</u> examination of the signalling arrangements as per 16.74.2)	this clause could be intended to cover the situation on a small mine where there is no appointed Engineer, but it appears to conflict with the next clause 16.74 appears on the list of Regulations excluded for small winding plants by Regulation 16.95.1, but then is reinstated here the requirement for a <u>daily</u> examination of the listed components as per 16.74.1 is in conflict with the subsequent clause of the Regulation

Table 3.4 Mining Regulations applicable to small winding plants (contd)

Regulation	Synopsis	Comment
16.95.1 (contd)	the Engineer shall appoint any competent person to examine at least once in each week the following items as listed in 16.74.1 : ▪ the winding ropes; ▪ the connections of the ropes to the drums; ▪ the connection between the winding rope and the conveyance, and the conveyance and any trailer or other attached conveyance; ▪ the conveyance and any main members by which they are suspended; ▪ the pulley wheels and sheaves; ▪ the brakes; ▪ the depth indicators; ▪ the safety devices; and ▪ all external parts of the winding engine.	the requirement for a daily examination on licensed winders has been amended to a weekly examination this conflicts with the preceding clause in the Regulation, where a daily examination is specified the need to examine the signalling arrangements and safety devices every week as covered by 16.74.2 is omitted here
16.95.2	a record book or card index system may be used in place of the Machinery Record Book.	
16.96	the Engineer to satisfy himself that the driver of a small winding plant is competent	

Table 3.4 Mining Regulations applicable to small winding plants (contd)

Regulation	Synopsis	Comment
Other Regulations in Ch 16	there may be other Regulations within Chapter 16 which could be construed as being applicable to small winding plant, for example:	
	16.33: a winding rope shall not be used if the breaking force at any point in the rope is less than nine-tenths of the initial breaking force	we were advised by an Inspector of Machinery that, in a recent court case, Regulation16.33 had been deemed to be applicable to small winding plant. This would imply the need to comply with Regulation 16.25 (test of new rope) and also for regular rope strength testing
	some Regulations that are not applicable are being used voluntarily	typically the Code of Signals as per Regulation 16.45
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	in practice, 2.13.12 allows the Mine Overseer to supervise machinery, with the authorising letter from the Inspector usually requiring that he does so in accordance with a code of practice issued by the Engineer. However, it is possible that the Engineer does not know of the appointment of the Mine Overseer, nor of the need for a code of practice there is a great chance of an overlap of areas of responsibility in this case
	▪ the proper operation and running of machinery	"conveyance of persons" is excluded in the following clause but not excluded in this first clause
	▪ the erection, moving or removal of machinery not used for the conveyance of persons	
18.8.1	On any rail track where any vehicle is attached to a rope operated by a winch or haulage engine….	this set of Regulations could be interpreted as applying to winding in an incline shaft
18.8.4.1	adequate number of effective safety devices	
18.8.4.2	devices to reset automatically where possible, and be operated from a position of safety	
18.8.5	daily examination and report on signalling and all safety devices done by a competent person	

Table 3.5 Regulations specifically excluded from applicability to small winding plants by Regulation 16.95.1

Regulation	Synopsis
16.5.1	Can be readily slowed or stopped and can be restarted immediately in either direction
16.5.2	Can lift the maximum unbalanced load
16.7	Depth Indicator
16.9	Overwind prevention device and overspeed prevention device
16.10	Speed indicator and tachograph
16.11	Construction of conveyances and cages
16.12	Skip or kibble used for persons to have roof
16.13	Roof or cover etc for shaft exam
16.14	Examination platform
16.15	Use of trailer in shaft when conveyance used for persons
16.18	Annealing requirements
16.19	Record of heat treatment
16.24	Spare rope in reserve
16.25	Test of new rope
16.26	Test of old rope to be re used
16.27	Examination of attachments and test run
16.28	Particulars of new rope to Inspector
16.29	Particulars of old rope to be re used to Inspector
16.41.1	Cutting, recapping and testing
16.41.2	Rope testing & certificate
16.49.1	Code of signals to be displayed
16.58	Detaching hooks
16.59	Retarding device
16.60	Over run clearances
16.61	Over run clearances
16.74	Daily examinations
16.75	Weekly, monthly, annual examinations by the Engineer, incl. test
16.81	Driver’s log book

3.4. Generic Hazards

The significant generic hazards related to the operation and maintenance of small winder installations and peripheral activities are:

1. struck by runaway conveyances;
2. struck by unexpected or uncontrolled movement of conveyances;
3. derailments;
4. contact with moving machinery or moving parts of machines; and
5. slipping and falling from heights

An explanation of these hazards and the conditions that are likely to be influential in the cause of these hazards are outlined below.

3.4.1 Runaway conveyances

The consequences of a runaway conveyance are likely to be significant both in terms of safety and in the costs of damage to both mine infrastructure and the winder system itself. Runaway conveyances were identified as a significant potential hazard in all the incline small winder systems examined. The primary causes of a runaway are likely to be rope failure, coupling failure or brake failure. Conditions identified which are likely to predispose such failures include:

◊ generation of excessive forces in ropes and couplings when the passage of the conveyance is suddenly obstructed, when excessive slack is taken up or when uncontrolled braking takes place;

◊ use of ropes that have been subjected to excessive wear and tear - damage resulting from kinks caused by the generation of excessive slack, contact with sharp objects and the effects of corrosion is of particular concern;

◊ use of inappropriate types of coupling device;

◊ failure to comply with safe coupling procedures;

◊ limitations in inspection, testing and maintenance regimes;

◊ failure to provide fail to safe or appropriate back-up braking systems on winders;

◊ failure of critical components in braking system; and

◊ ineffective training and/or supervision of mine staff.

3.4.2 Unexpected and uncontrolled conveyance movement

Injuries caused by an unexpected or uncontrolled movement of a conveyance were established as a significant potential hazard on all the small winder installations examined by the project. Potential problems were identified in relation to conveyances attached to winder units and to those being hand trammed on shaft stations. Conditions which are a likely to lead to injuries included:

◊ **underwind and overwind situations** – people struck by a conveyance which fails to stop at a pre-determined or expected place are likely to be severely if not fatally injured. This situation applies to people engaged in both vertical and incline winder operations;

◊ **hand tramming operations** – the safety of people engaged in hand tramming operations is a major concern at most mines where rail transport systems are employed. There was a high risk of people being crushed between or knocked down by conveyances moving out of control. On small winder systems the risk of such accidents occurring during the transfer of conveyances between incline shafts and shaft stations can be greater as a result of operators needing to adopt an exposed position in order to operate the transfer point mechanism. These problems are further compounded by steep gradients, bends in the immediate travelling way, confined space working environment and poor illumination;

◊ **communications –** poor communications were often cited as an influential factor in the cause of mine accidents, especially those associated with operations which depend upon effective teamwork and involve the control of mobile equipment. On small winder systems, the risk of such accidents occurring was considered to be high due to the nature of the working environment and a high dependence on direct visual and spoken communication, warning signals, signalling systems and telephone networks;

◊ **operator error** – errors made by winder drivers, banksmen and onsetters were identified as having the potential to cause accidents through the unexpected or uncontrolled movement of a conveyance. Conditions identified as being likely to predispose operator error included limitations in: operator training; written working procedures; standards of supervision; communications; the operating environment; and the standard of ergonomics applied to the design of small winder controls; and.

◊ **personnel positioning** – the risk of being struck due to unexpected movement of a conveyance increased due to a failure: by people to recognise hazards and adopt a position of safety; and mines to provide properly demarcated areas and appropriate refuges and/or safety barriers.

3.4.3 Derailments

Derailment is a major concern in all underground mines wherever rail transport systems are employed. For these systems to operate safely and efficiently management at the mine must appreciate the limitations of their control and use. While improved standards of installation and maintenance have reduced the number of derailments in locomotive haulage systems, there is little evidence to suggest that similar gains have been realised in the context of inclined winder systems. Derailments were identified as a significant potential hazard in all the inclined small winder systems examined. The primary causes of derailments were identified as:

◊ **poor standards of installation and maintenance of track** - conditions which are likely to cause or contribute to a derailment included misaligned, loose or damaged rails, inadequate rail-bed stability, defective switch mechanisms, excessive cross-gradients and gauge variance. Poor track standards also lead to damage to conveyances, the use of which also contributes to the risk of derailment as outlined below.

◊ **objects lying on the track** - foreign objects of sufficient size and mass which can lead to derailment included items shed from conveyances, fallen rock, tools, equipment and other items left by maintenance and operating teams;

◊ **obstructions in the travelling** way - intrusions into the clearance envelope of a conveyance which had the potential to derail a conveyance include bank doors, drop sets and arresting devices, hanging and side wall incursions, items of infrastructure and plant located too close to the track;

◊ **conveyance condition** – the condition of a conveyance has a significant influence on derailment potential. Insufficient axle clearance, incompatibilities in coupling arrangements, damaged or badly worn wheels and couplings were all identified as factors with the potential to increase the risk of a derailment; and

◊ **load condition** – unbalanced loads or loads that shift during transportation also increase derailment potential.

3.4.4 Moving machinery and parts of machinery

Contact with moving machinery or moving parts of a machine was identified as a significant potential hazard in all the small winder systems examined, particularly the incline winders. The following types of potential hazards were of particular concern:

◊ caught up and entangled in the moving parts of the winder machinery, particularly winder drums and sheaves;

◊ struck by a broken rope – the release of elastic strain energy associated with a broken rope in a confined space leads to a high probability of severe and multiple injuries to those in proximity; and

◊ crushed by a drop set or drop rail – being hit by a falling drop set or drop rail is likely to result in a severe or even fatal injury.

3.4.5 Slipping and falling from heights

Small winder operations involve wide ranging activities where there is a risk of falling. Slipping and falling from heights was identified as a potential hazard at all the installations examined. The dangers are associated not only with a wide variety of working places but also the means of access to them. Pre-work and routine safety inspections also involve similar risks of falling. The following types of potential hazard are of particular concern:

◊ falling from headgear when carrying out inspection and maintenance work;

◊ falling down shafts and steep inclines when engaged in activities on the bank, shaft station or loading boxes;

◊ falling from ladders when climbing in and out of shafts; and

◊ falling from conveyances or landings in shafts, especially when moving from station to conveyance and vice versa.

Conditions which are likely to predispose such accidents include limitations in the following:

◊ the use of appropriate fall arrest equipment;

◊ the provision of safe methods of access into and out of conveyances;

◊ the provision of safe landings, steps and platforms;

◊ the provision of adequate fencing and barricades;

◊ the provision of appropriate handholds and handrails;

◊ the maintenance of ladders and access routes in a safe condition; and

◊ the provision of effective training and supervision.

3.4.6 Falling objects

The risk of people being struck by falling objects was identified as a significant potential hazard in all the vertical and steep incline small winder systems examined. People were identified to be at risk not only in a wide variety of work places but also when travelling to and from their normal place of work. The following types of potential accident are of particular concern:

- ◊ people working on the bank struck by objects falling from headgear;
- ◊ people being transported or climbing in and out of the shaft struck by objects falling from the bank; and
- ◊ people on shaft stations and at other places in the shaft struck by items dropped by shaft maintenance crews or debris dislodged from penthouses by people climbing ladders.

Conditions which are likely to predispose such accidents include limitations in the following:

- ◊ the provision of kickboards and effective use of doors at shaft entrances;
- ◊ the provision and use of canopies on conveyances used for man-riding;
- ◊ the planning and organisation of tasks which create a risk of falling objects at safe periods;
- ◊ the maintenance of ladders and access routes in a safe condition;
- ◊ the provision of refuges and safe areas for people when other tasks are conducted which create a risk of falling objects; and
- ◊ the provision of effective training and supervision over people involved in activities where there is a potentially high risk of being struck.

3.5. Assessment of controls

The risk assessments carried out by the project elicited a considerable amount of important information on the effectiveness and reliability of the control measures currently used by mines to reduce the levels of risk associated with the types of hazards described in the previous section. The wide range of common controls identified and the common shortcomings associated with these controls are presented and discussed below. They have been grouped and considered in terms of the controls associated with:

- winder machinery;
- ropes;
- physical barriers and devices for arresting conveyances and other equipment;
- conveyances and attachments;
- shaft and shaft equipment maintenance;
- safe positioning of personnel;
- falling from heights;
- winder operator reliability; and
- falling objects.

3.5.1 Winder machinery

A wide range of control measures were identified as being associated with the winder machinery. These were predominantly engineering controls that had been designed into the systems, and differed depending, for example, on whether the winder was a vertical or incline installation, and whether it was licensed or non licensed.

Engineering controls

The following engineering control measures were identified during the study:

- Over-wind protection. This is intended to prevent the conveyance from travelling past its end of wind position, which would be above the bank for man and material winding and just above the tip for rock hoisting. On the licensed winders it was provided by means of purpose-built electromechanical controllers (eg Lilley controllers or cam gear units) driven from the winder drums, as well as cams and switches on the depth indicators. Self-checking features are often used to monitor the integrity of these safety devices. On unlicensed units, overwind protection is not a legal requirement but was fitted on all the winders seen, being operated by switches and cams attached to the depth indicator.

  Many winders also had 'tarzan' trip wires in the headgear as the ultimate limit in case other overwind devices failed to operate.

  A three turn warning device was also often used; this sounds a warning signal when the ascending conveyance is three turns of the winder drum away from the bank.

- Lock bell signalling systems used for interchange of signals between the driver and the bank and between the driver and the various stations, the bell operators being specifically authorised and in possession of "keys" which have to be inserted into the bell box before signals can be given. The system has two circuits, so arranged that the driver can distinguish between signals received from the bank and signals received from the stations. The system is also interlocked with the winder brakes to prevent inadvertent movement of the winder, and depends on a sequence of signals to permit the driver to release the brakes.

- Dual braking systems. All the winders had dual braking systems, either as an emergency thruster operated brake attached to the high speed shaft or, on double drum winders, as brakes fitted to each drum, each of which could provide the total required braking effort.

- Over-speed alarm and trip. These are provided to warn the operator and automatically brake and/or stop the winder should excessive winding speeds be generated, and were only noticed on licensed winders.

- Brake condition monitors. These provide a warning to the operator when the brake linings become worn and need replacing. They are normally fitted to licensed winders, none of the unlicensed winders examined were fitted with such a device.

- Drive power indication by means of an ammeter. In addition to indication of power during normal operation, the ammeter is also used as an indication of brake holding power during brake testing. An overcurrent protection trip can also be fitted in the same circuit.

- Underwind protection. These are similar to the overwind protection devices described earlier and typically consist of Lilly devices and mechanically operated switches as previously described.

The following engineering control measure is associated specifically with incline winder systems:

- Marshall's device. This is used on incline shafts and consists of wires run down the shaft on either side of each winding compartment. Should a derailment occur a signal is provided to warn the driver, automatically trip the winder and apply the brakes.

The following shortcomings were identified with the above engineering controls.

◊ Overwind protection

  - on incline shafts, whilst transporting long loads such as pipes, the overwind protection device is often disconnected so that the conveyance can be taken up to almost the top of the incline, past the end of wind position, thus allowing for easier handling of the materials at the bank; and

  - on some installations examined, overwind protection devices had been left disconnected. This could be brought about by situations such as those described above. This places a considerable onus of responsibility on winder operators if overwind incidents are to be avoided.

◊ Lock bells on unlicensed winders.

In several instances mine staff said that they were using a "locked bell system", while in fact the installation did not comply with the Regulations, for example:

❖ bank bell and shaft bells on one electrical circuit (non-compliance with Regulation 16.43.2 (b));

❖ winder brakes not interlocked with the locked bell system (non-compliance with Regulation of 16.43.5).

In many cases staff were not conversant with these requirements. The use of the term "locked bell system" to describe an installation that is in fact not in accordance with the accepted specifications could create an illusion of design and operational integrity. Other shortcomings associated with locked bell systems were:

❖ anecdotal evidence of the key to the locked bell system being given to unauthorised persons in order to speed up shaft operations;

❖ anecdotal evidence of the use of "open bells" ie an informal arrangement between the driver and banksman/onsetter to avoid the use of signals which lock the winder brakes, where this interlock was fitted;

❖ the use of "short bells" to expedite shaft operations. This informal practice involves using simple signals instead of the formal interchange of a sequenced communication foreseen by the Regulations, particularly when handling explosives or material;

❖ confusion regarding the code of signals. It is common practice for the mine's procedures to state that the Government Code of Signals is to be used, and indeed the correct notice is usually displayed on all stations. However a much simpler version of the Code is often used in practice;

- ❖ lack of knowledge of onsetters and banksmen in the use of the Code, especially for handling material and explosives; and

- ❖ multiple lock bell keys in use on one shaft. This could give rise to the situation where a conveyance situated on one station could be moved by the driver when the bell is rung by another person on another station.

Other shortcomings associated with engineering controls were:

- ◊ the operator sometimes cannot hear the three turn warning alarm due to background noise levels, thus increasing the risk of an overwind;

- ◊ under-wind protection was not provided on incline material shafts, where the configuration of lower stations makes this difficult, and this increased the risk of conveyances over-running and colliding at stations;

- ◊ concern was expressed by the OEM's regarding the effectiveness of thruster brakes in an emergency situation. On the older winders, these brakes are designed merely as a "parking" facility and do not have the thermal capacity to stop a conveyance descending at speed;

Procedures and Training

The following procedural control measures were identified in relation to braking and control systems and are common to all applications of small winders:

- routine inspection and testing of winding machinery; and

- all licensed winding plant should have a Machinery Record Book in which the inspections and tests are formally logged. In the case of unlicensed winders a record book or card index system is required for this purpose.

The standards for and effectiveness of these control measures differed from mine to mine. A wide range of inspection and testing regimes were identified ranging from pre-use checks by winder operators to detailed inspections carried out by electricians, and from dynamic tests on winder brakes to non-destructive testing of other critical components. The following shortcomings were identified on unlicensed winders:

- ◊ inspections and brake tests were not always carried out routinely according to the standard defined by the mine. The results of such inspections and tests were not always formally logged in the appropriate record book. The winder driver does not always complete his pre-use checks properly, or have the correct pre-use check form, and the results of such inspections and tests were not formally logged in the appropriate record book. The pre-use checks were not always over-inspected by supervisors, and so any necessary corrective actions are not always undertaken;

- ◊ it is normal practice for the driver to test the main brake against the motor current as part of his pre-shift check. However, many shortcomings were noted on unlicenced installations, including the following;

    - ❖ ammeter not working or visible to driver;

- ❖ engineering staff have not determined or are not aware of the acceptable current at which the brake should hold or at which the power would trip;
- ❖ ammeters are not marked with this reading; and
- ❖ some drivers are unaware of this procedure.

There were a number of problems identified with the provision and design of ammeters used to test the braking systems, and the shortcomings are described fully in Section 3.4.8.

◊ Engineering tests. There are no regulatory requirements for the testing of brakes on small winding plant. It appeared that testing of the emergency brake was problematic, with the following points being noted:

- ❖ in order to apply power without lifting the thruster brake, the electrician has to override an electrical interlock. Proper arrangements for this are rarely provided, with the electrician having to fiddle inside the live panel to achieve the objective;
- ❖ some staff are not aware of the need for this test;
- ❖ some staff do not know the current reading at which the power should trip; and
- ❖ ammeters are not marked as noted above.

The following additional control measures are applicable to licensed winders:

◊ dynamic tests on winder brakes carried out every six months by specialists, often by external agencies; and

◊ modern practice on large winders is to parallel the mandatory annual visual inspection of critical brake components with a non destructive test. These tests are not required on unlicensed winding plant. However, these small winders are often installed in remote areas of the mine in damp conditions; the lower brake pins, being close to floor level, are particularly susceptible to corrosion. On most winder designs these lower pins are not easily accessible, and are thus very difficult to remove.

3.5.2 Ropes

Engineering controls

The following engineering control measures were identified to prevent the failure or the misuse of ropes:

- shaft rollers provided between the tracks on the footwall on incline shafts to reduce rope wear brought about by the rope rubbing against the floor;
- a slow braking mode on the winder unit which is activated following an overspeed trip. This applies the brakes gradually, preventing the winder from coming to a sudden halt and overstressing the rope, either directly when the conveyance is descending or by causing a slack rope condition when the conveyance is ascending; and
- a slack rope device provided on winders operating in vertical shafts. It warns the driver and trips the winder if slack rope has been paid out indicating that the conveyance is stuck in the headgear or the shaft. This device consists of a wire that is stretched

across the rope opening in the winder house, and which is attached to a limit switch. If slack rope is paid out , the slack will move the wire and operate the switch.

The following shortcomings were identified:

◊ shaft rollers had been purposely removed in order to allow passage for a low loader material car, and not replaced;

◊ shaft rollers had been damaged through the use of an incorrect low-profile material car on the incline;

◊ shaft rollers had been damaged due to corrosion brought about by excessive water and the accumulation of dust and dirt;

◊ a lack of appreciation on the part of mine staff of the need for proper slow braking facilities. OEMs noted that winders are often moved around from one installation site to another, and there appears to be insufficient investigation of the winder design related to the proposed duty. Often the only factors looked at are power and rope pull, whereas slow braking characteristics are a very important part of the overall winder suitability; and

◊ a lack of appreciation on the part of the mine staff of the need for raise/lower discrimination, to apply the braking force at different rates to suit the two different situations that occur when raising or lowering a load.

Procedural controls

Many procedural control measures are currently used on winder systems to ensure that the winding ropes are properly examined and tested to ensure their continuing fitness for use. These controls include:

- for licensed winders:

Type of control	Reference	Control
Load test	Regs 16.25, 16.26	ropes to be load tested before being put on
Cut front end	Reg 16.41.1	front end of rope to be cut at intervals not exceeding 6 months
Test of cut front end	Reg 16.41.2.1 et seq.	test to be performed to determine the actual breaking strength and general condition of rope
Cut of back end	-	back end cut to change position of high wear crossover points on the rope
Examination	16.74.1 16.75.3	daily examination of winding rope by competent person monthly examination of rope by engineer
Non destructive test	-	magnetic rope testing is used to assess the internal condition of the rope and identify broken wires inside the rope structure.
Standard	SABS 0293	defines the procedures to be used for visual and magnetic testing, gives discard criteria and provides for certification of operators

Rope record book	16.79 et seq.	defines the requirements for recording details and inspections of ropes

- for small winding plant:

Examination	16.95.1 / 16.74.1	weekly examination of winding rope by competent person

As far as small winding plants are concerned, mines apply a variety of inspection regimes with topics selected from the tables above. The following general observations were made:

- ❖ the size of mine and the presence of a “licensed winder” culture had a great impact on the range of inspections stipulated for small winding plant and the availability of competent staff to undertake the work;
- ❖ the duty of the winder had a significant influence: a heavily used winder generally had a higher level and quality of inspection than others; and
- ❖ weekly shaft examinations that are formally logged. These should examine the condition of shaft rollers in incline shafts.

The following shortcomings were identified:

◊ many comments were made regarding shortages of properly skilled staff for rope examinations. On licensed winders, rope inspections have traditionally been carried out by qualified rigger/ropemen. On small winding plant installations in the production sections of the mine, there is a tendency for the weekly rope inspections to be carried out by several classes of competent person;

◊ riggers, who are familiar with the movement of heavy material but who are not necessarily trained in rope inspection; and

◊ other “multi-skilled” artisans such as fitters who may not have undergone a proper course in rope inspection.

It must be recognised that the trend in the industry is in the direction of multi-skilling, where artisans with a basic competence in one trade (eg fitting) are trained to undertake basic tasks in another trade (eg rigging). Multi-skilling courses are better administered on large mines with effective training departments, and there must be cause for concern regarding the skill level of this type of staff on small mines;

◊ the front end of the rope is subject to the most damage from abrasive wear and corrosion. Not all mines appear to cut front ends regularly, but users and OEMs supported the view that regular front end cuts should be rigidly enforced; and

◊ rope inspection records for unlicensed winders were not always completed as specified by the mines standard.

Procedural controls - incline shafts.

These included:

- mine standard procedures whereby the transportation of heavy or awkward loads is to be undertaken by a rigger;
- signage around the bank and shaft stations indicating the maximum number of material cars that can be connected to the pilot car at any one time, as well as the maximum type of loads that can be transported (e.g. maximum number of pipes, cement bags etc); and
- working practices on the bank and within the shaft stations that reduce the risk of rope damage due to a slack rope condition. This is particularly important when lowering the conveyance over the brow at the top of the incline, where this design of incline is used, and when lowering conveyances onto shaft stations.

The following shortcomings were identified:

◊ conflict between the signage on the bank or shaft station and the mine's written standard procedures regarding the number of material cars that can be connected to the pilot car during a single run;

◊ signs located around the shaft station regarding the maximum loads for material cars were sometimes outdated and/or illegible; and

◊ rope manufacturers report considerable problems with the rope front ends, due to kinks (caused by uncontrolled loading of a slack rope) and abrasive wear (caused by ropes dragging on the footwall when slack).

3.5.3 Physical barriers and devices for arresting conveyances and other equipment

This category of control measures are designed to provide a means of arresting any uncontrolled movements of conveyances used on incline winder installations and also the movement of other mobile equipment used in peripheral activities associated with small winder operations generally. Engineering controls and controls associated with workplace design are of particular relevance here.

Workplace design and engineering controls

The following workplace design and engineering controls were identified:

- safety drop rails – typically located on a rail track across the entrance to shaft stations. Their function in such a location is to prevent inadvertent access of vehicles (such as may be used on the working level of the mine) to the shaft, as required by Regulation 16.61.2.1. Special interlocked safety drop rails (the "vula-vala device") are used at the brow of inclines to form an "airlock" and so prevent vehicles and material cars entering the shaft except under proper control;

- safety drop sets – used in incline shafts as safety barriers to stop runaway cars proceeding further down shafts;

- in some small winder installations, winder operators are provided with warning lights which indicate whether a drop rail or drop set has been raised or lowered to its correct operating position;

- protective fencing, barriers, tank traps etc. designed to prevent the unexpected or uncontrolled ingress of equipment into areas such as banks or shaft stations where people may be working;

- bank doors over steep incline or vertical shafts to prevent inadvertent entry by conveyances into areas where people may be working;

- use of stop blocks, chain sprags and aeroplane sprags on shaft stations to prevent 'loose' conveyances from moving;

- 'Blair devices' on pilot cars which automatically slow down and derail a conveyance if the rope tension at the rope attachment is lost; and

- barriers across winder rooms to provide protection to winder drivers in the event of an over-wind situation.

The following shortcomings were identified:

◊ counterweight mechanisms on some safety drop rails and drop sets were incorrectly fitted with the result that the rails failed to make contact with the ground when fully lowered. If the rails do not rest on the ground, the force on impact is likely to be sufficient to detach the drop rails from their anchor points;

◊ in many cases the strength of attachment mechanisms on safety drop rails and drop sets appeared to be inadequate for the probable impact load that would be applied by a runaway conveyance;

◊ safety drop rails and drop sets in some shafts had been 'tied off' in a raised position while winding operation continued, thereby negating their effectiveness as a control. Inquiries indicated that they had been left in this position due to failure to repair defects in the operating mechanisms;

◊ in some cases safety drop rails had been located to one side of a shaft such that in the event of an impact, a conveyance would be derailed onto the populated station side of a shaft;

◊ tank traps which incorporate the use of transfer cars are often mis-used with the result that vehicles were allowed to approach a shaft while winding operations are taking place; and

◊ bank doors, when provided on an incline shaft, were not always reliably used with the result that they may not be effective in preventing a conveyance from entering a shaft.

3.5.4 Conveyances and attachments

Generally, in material hoisting incline shafts, a pilot car is attached to the end of the winding rope to provide a load which will assist in rope coiling when raising and guide the rope down the shaft when lowering. Material car(s) are then attached to the pilot car, usually by wire rope slings. When a pilot car is not used, the material car(s) are attached directly to the end of the winding rope.

Safety slings are fitted over the cars, from the upper rope attachment to the lower coupling of the bottom car, which act as a backup attachment should any of the intermediate connections fail.

The primary control measures are engineering or technically based in that all slings and associated coupling equipment should be certified and/or produced to an approved/specified (mine) standard. These are:

- the rope attachment to the pilot car to be properly designed, manufactured and tested;
- the pilot car to be properly designed and manufactured for the duty envisaged;
- the wire rope slings and the coupling pins used to connect the material car to the pilot car to be purchased to a correct engineering specification from reputable suppliers;
- the safety slings over the cars to be purchased to a correct engineering specification from reputable suppliers; and
- the material cars to be designed for use on the correct inclination, and maintained in a safe operating condition.

Procedural controls for licensed winders included:

- daily examination of attachments by an appointed fitter, formally recorded in log book;
- daily examination of the conveyance by the appointed fitter or boilermaker, formally recorded in log book;
- monthly examination of the attachments by the responsible engineer, formally recorded in log book;
- duty rotation of rope attachment sets; and
- examination and non-destructive testing of the rope attachment every 6 months;

Procedural controls also used on unlicensed winders included:

- a daily check on condition of all equipment by the banksman or bell man;

- a daily examination of the pilot car/winding rope attachment by appointed engineering personnel;

- sometimes the pilot car/winding rope attachment is subject to an annual NDT examination;

- regular inspections of slings and coupling pins by appointed engineering personnel (either a fitter or a boilermaker). Typically this is undertaken daily, with a 6 monthly examination being done by the engineer;

- weekly examination of pilot and material cars by a boilermaker;

- weekly examination of safety slings by an appointed rigger; and

- procedures for the use and control of slings. Typically, this involves slings being logged, date stamped or colour coded and replaced after 12 months in service.

The following shortcomings were identified:

◊ banksmen and onsetters were not sufficiently aware of the potential hazards related to equipment under their control. As a result, despite knowing that they were not following the correct procedure, they often had no background on the reason for the procedure or the likely consequences of not following it;

◊ use of incorrect coupling equipment and improvised coupling practice. This was due to:

  ❖ a lack of spare coupling slings and pins at the bank or station, especially on afternoon and night shifts; and

  ❖ using incompatible and/or non-standard material cars that have different coupling designs.

◊ lack of proper inspection of coupling pins. In one case, neither the engineering or operating departments of the mine considered this to be within their areas of responsibility Hence, they were not routinely inspected;

◊ use of material cars that were not suitable for use on an incline. In order to carry the imposed loads satisfactorily under all conditions of use, the material car should be fitted with a solid drawbar between the two end frames of the chassis. It was noted that material cars in use generally throughout a mine are usually allowed free movement in the incline shafts;

◊ this problem of the use of material cars throughout a mine also mitigates against the formalised regular inspection of material cars which are suitable for incline use.;

◊ use of safety slings that were too long for the application. In the event of failure of the intermediate couplings, the slack safety slings would not be able to sustain the impact load from the uncoupled cars as momentum is gained. It was noted that, in general, operating staff were unaware of the importance of this issue;

◊ safety slings not regularly inspected. This is because:

  ❖ inspections and changes of slings are not always logged by the rigger; and

- ❖ slings are often taken away from the shaft into the mine to be used for other purposes.

- ◊ where safety slings are date stamped, there was confusion as to whether the date referred to was purchase, in-service, or expiry date.

3.5.5 Shaft and shaft equipment maintenance

The following procedural controls associated with shaft and shaft equipment maintenance were identified:

- weekly shaft examinations undertaken by the shaft timberman, often accompanied by the responsible boilermaker/fitter;
- regular inspections of the shaft by the area safety officer;
- daily inspection of the shaft (and loading boxes if used) by the shift boss;
- regular maintenance of the loading chutes and loading boxes (if used); and
- regular maintenance of shaft equipment and fittings as required.

The following shortcomings were noted:

- ◊ the daily shaft inspections are done from the ladderway. If any defect in the winding compartment, or spillage in a rock hoisting shaft, is noted, it is onerous to follow the laid down lockout procedures before entering the winding compartment to undertake minor repairs or cleanup;
- ◊ often the weekly shaft examinations and planned repair jobs are constrained by production pressures;
- ◊ comment was made regarding the shortage of skilled shaft timbermen; and
- ◊ illumination is usually only provided at stations, not in the whole length of the shaft.

3.5.6 Safe positioning of personnel

This classification of controls is designed to prevent people from adopting potentially unsafe positions where they are at risk from being struck by moving equipment or machinery such as conveyances, drop sets, winder drums, sheaves etc. Similar controls designed to prevent people from falling and being struck by falling objects are dealt with in Sections 3.5.7 and 3.5.9 respectively.

Controls designed to physically prevent workmen from taking up positions or undertaking activities where they may be at risk

These controls include:

- guards and handrails around moving parts of machinery in, for example, winder control rooms and headgear.
- ladders and stairways in shafts fenced off or screened from conveyance ways;

- correctly used lock-bell systems allow people to work and undertake maintenance activities in shafts under controlled conditions without a risk of being struck by moving conveyances or caught up in other moving parts of winder systems;

- station layouts which incorporate safe working positions for onsetters while operating safety drop rails and safety drop sets.

- bank doors over vertical and steep incline shafts reduce the risk of people being hit by moving conveyances while working in shafts;

- demarcated areas of safety and appropriate refuges where people can go for protection when activities are carried out which may place them at risk from being hit by moving equipment or machinery;

- protective fencing, screens, barriers, tank traps etc. to prevent the unexpected ingress of equipment into areas such as banks or shaft stations where people may be working;

- winder drive position protected by barriers or isolated from moving equipment.

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

These controls include:

- bells on lock-bell systems provide warnings to workmen of imminent movement of conveyances.

- lights momentarily dim or flicker automatically in shafts to provide a warning to workmen of approaching conveyance.

- warning lights provided in travelling ways to warn people when winder is about to, or is operating;

- good standards of Illumination coupled with clear fields of vision reduce the risk of workmen being unexpectedly struck by moving equipment;

- warning signs placed in front of moving machinery such as winder drums or sheaves; and at entrances to areas of high activity such as banks or shaft stations where the risk of being struck by a moving conveyance is particularly high;

- visual contact between workmen increases their ability to communicate reliably which can reduce the risk of accidents particularly during hand tramming activities on shaft stations and banks.

The following shortcomings were identified:

◊ tank-traps which incorporate the use of ‘transfer cars’ were often not used in accordance with laid down procedures, with the result that there was a “straight through” path to the shaft and vehicles were able to approach the shaft while winding operations were in progress;

◊ in some winder installations, people working on shaft stations or loading box areas were not adequately protected from being struck by moving conveyances. The handrails provided round the shafts were too low and did not prevent them from leaning or reaching over the open shafts into the path of the conveyance.

Procedures

A range of safe working procedures produced to ensure that people stand in a position of safety while carrying out their work or while other potentially high risk activities are performed were identified. In particular, safe working procedures were identified covering:

- roles and responsibilities of onsetters and banksmen in relation to the clearing of shaft station and bank areas of unauthorised people before winding and other related activities commence;
- safe positioning of workmen involved in the transfer of conveyances between inclined shafts and shaft stations using station dropsets and while working over brows;
- methods of locking-out and communicating to prevent unexpected operation of movable parts of winders while inspections and maintenance work is carried out;
- correct methods of work to be employed to reduce the risk of men getting caught in moving machinery in headgear;
- access of only authorised people in loading box areas;
- positioning of workmen in steep incline shafts while conveyances are in motion;
- loading and unloading of conveyances on banks and shaft stations;
- travelling and undertaking maintenance activities in vertical and steep incline shafts;
- correct methods to be followed when using man-riding conveyances;
- safe methods of transferring abnormal loads onto shaft stations from mine haulages.

The following shortcomings were identified:

◊ workmen climbing out of shafts onto shaft banks on surface were often at risk from being hit by vehicles. Physical barriers and working procedures did not adequately control the risk of such events; and

◊ safe working procedures are not always followed especially when they are perceived to impair production or progress. In some cases workmen elected to breach these procedures by their own volition and in other cases they were instructed to violate safe working practices by their immediate supervisors. An example of this involved hand tramming conveyances on station drop sets. Written procedures stipulated that workmen should not hand tram or take up a working position on station drop sets due to a high risk of falling or being struck by moving conveyances. However, in some installations, conveyances would not roll freely on the drop sets, and in such circumstances workmen had to adopt a position on the drop set in order to move the conveyance.

3.5.7 Falling from heights

Protective barriers and workplace design

A wide range of protective control measures associated with the design and organisation of workplaces were identified. These included:

- protective fencing, screens & barriers;
- handholds and handrails;
- properly designed access stairways and ladders;
- access landings, steps and platforms;
- use of non-slip materials on steps and walkways;
- level floors and covered trenches or gullies near shaft openings;
- illumination and clear fields of vision in areas of greatest risk;
- bank doors over vertical and steep incline shafts;
- backhoops and platforms on long ladder runs.

The following shortcomings were identified:

◊ the rungs on some ladders were too close to the footwall to provide workmen with a secure footing. In some places they were able to place only the tips of their toes on the ladder rung and it was not uncommon for them to slip;

◊ it was not uncommon for rungs to be badly bent which also prevented workmen from gaining a secure footing;

◊ a failure to provide appropriate handholds and steps to help workers progress from the top of shaft ladders onto banks and vice-versa increased the risk of slipping and falling down shafts;

◊ some safety hoops were damaged and would have had limited value in preventing a fall. In some instances safety hoops had been damaged by falling ground and equipment to such an extent that workmen had to climb around them rather than through them;

◊ some platforms were also damaged by falls of ground and falling equipment. Without such platforms workmen were deprived of a place to rest and recuperate when negotiating a long climb, and furthermore, they faced an increased risk of slipping and falling when transferring from one section of ladder to another without a platform;

◊ sometimes the landings and platforms adjacent to shafts were wet and slippery, which increased the risk of slip and fall accidents for people boarding and alighting, loading and unloading and carrying out inspections and maintenance on conveyances. In some cases no attempt had been made to divert water away from the working areas or provide a design of floor which provided workmen with a reasonable footing when wet;

◊ handrails on platforms, landings and walkways were not always continuous and secure. In some installations, gaps existed at critical points where work had to be conducted creating potential fall situations. In other cases the temporary rails across these areas were insecure;

◊ bank doors left open increased the risk of people falling down shafts. Poor lighting levels, uneven ground conditions and debris lying on the ground near the opening and a failure to fence off or barricade the area further increased the risk, especially during hours of darkness and periods of low visibility;

◊ some bank doors had to be opened and closed manually. These doors are normally very heavy and are not always fitted with handles. The actions involved in regularly carrying out this activity placed people at risk of falling down the shaft;

◊ some conveyances lacked safe access and egress provisions, particularly in terms of the provision of adequately considered hand holds, foot steps and platforms to bridge the gap between station landings and conveyance;

◊ failure to consistently cover cable trenches and gullies located in proximity to shaft openings;

◊ walkways were not always clearly demarcated with the result that workmen sometimes moved outside safe areas where there was risk of a fall;

◊ lighting restrictions existed in some areas where there was risk of a fall. Problems included critical areas left in dark shadow, glare resulting from poorly located light sources and sudden changes from brightly lit to very dark areas;

◊ access ladders to headgear were sometimes located close to shaft openings. A failure to adequately barricade or cover the shaft increased the risk of people descending the ladders stepping into the shafts. The risk was particularly high at night in poor lighting conditions.

Procedures

The following procedural controls were identified:

- housekeeping arrangements aimed at removing conditions likely to predispose a fall;
- site safety inspections designed to identify and initiate remedial action to address conditions and working practices which were likely to increase the risk of a fall;
- safe working procedures produced specifically to cover high risk activities where special precautions and equipment should be used. Procedures were identified covering the use of fall arrest equipment, the correct methods of using of shaft/bank doors and carrying out tasks in headgear, on the surface in proximity of the shaft, loading and unloading conveyances, riding in conveyances, and working on shaft stations; and
- limits on the number of people allowed to ride in conveyances at one time.

The following shortcomings were identified:

◊ housekeeping standards were inconsistent with the result that conditions existed which were likely to create the risk of a fall. In one case, a failure to comply with standard instructions covering the safe stacking of supplies prevented a security/access gate to a shaft from being closed. Unauthorised entry could result in a fall down the shaft;

◊ a failure to follow up safety inspections with corrective action resulted in potentially unsafe working conditions. The damaged backhoops and penthouses on ladders referred to above and badly corroded treads in stairway steps were often resulted from a failure to implement such remedial action;

◊ inconsistencies existed in the standard of written procedures. Some procedures were of a high standard and set out in detail the hazards associated with a particular activity and the correct methods of work and precautions that should be adopted. Other procedures were however less detailed and specific – typically a standard procedure covering the unloading of a skip onto a shaft station platform stated simply that 'life lines should be used'. There was no instruction or guidance on what type of life line equipment should have been used or how it should have been used;

◊ inconsistencies also existed in the extent and coverage of written procedure in that there was a failure to provide such procedures for some high risk activities. An example of this involved a failure to provide safe methods of work for those involved in cleaning and lubricating guide rollers located under conveyances used in vertical shafts. To carry out this task it is the practice to wind the conveyances just above the bank to provide access to the rollers underneath the conveyance. Men were seen leaning over open shafts when carrying out this activity without wearing any form of fall arrest equipment;

◊ working procedures produced for people engaged in activities in headgear rarely addressed the influence of adverse weather conditions, such as high winds, rain, ice etc; and

◊ limits on the maximum number of people that can be carried in small conveyances was sometimes exceeded. This resulted in people travelling while standing on top of the protective canopies where they were placing themselves at risk from a fall;

Personal protective equipment

Where people are at risk of falling from a height, such as when maintaining headgears or carrying out maintenance work in vertical or steeply inclined shafts, some form of fall-arresting equipment incorporating a safety harness should be used. This can provide an effective method of reducing the severity of the injuries sustained by anyone involved in a fall providing the equipment specified is appropriate for the given application and is used correctly. However, the following shortcomings were identified in some of the fall-arrest arrangements used:

◊ appropriate anchor points were not always provided. To overcome this limitation workmen adopted improvised methods of work where they were not sufficiently protected from a potential fall condition;

◊ safety belts were sometimes used in preference to full body safety harnesses. It is now widely recognised that safety belts used for this purpose can cause severe internal injuries to fall victims;

◊ some fall arrest systems were specified which were not sufficiently flexible to enable tasks to be conducted without workmen following improvised and potentially unsafe practices;

◊ safety harnesses were used with single lanyards in tasks where it would have been safer to use lanyards in pairs. A single lanyard does not allow workmen to move to different positions without them being at some point disconnected. Two lanyards used in tandem allow them to move about with full fall arrest protection; and

◊ situations were identified where mines had either failed to recognise the need to specify the use of such equipment or failed to ensure that it was used consistently by work teams.

3.5.8 Operator Reliability

Ergonomics and human factors considerations – Potential Active Failures

Small winder installations are provided with a wide range of engineering controls which reduce the potential for operator error. Nevertheless, situations exist where reliable error free operation by winder operatives remains the key to safe operations. The key to ensuring operator reliability lies in a careful consideration of ergonomic and human factors issues associated with the design of the winder control station and the immediate working environment. Based on the results of the potential human error audits, the following ergonomics and human factors issues were identified as being the most influential in reducing the potential for error by small winder operators:

- design and arrangement of controls with particular regard to: the provision of appropriate type of control; dimensional characteristics; operating forces; speed and accuracy of operation; amount of displacement; location and layout in relation to the operator's reach and limb positions; compatibility between control and winder action; control – instrument display relationships; and emergency stop arrangements;

- design and arrangement of visual displays (indicator lights, illuminated buttons, digital and visual presentations, alarms and warnings, labels, instruction plates and information). Issues of particular importance include: choice of display type; location and layout in relation to operators field of vision and control positions; suitability in terms of operator requirements; compatibility with controls; and legibility, colour and attention gaining characteristics;

- operator's visual environment with particular regard to: fields of vision, viewing distances, visual obstructions and lines of sight to important visual attention areas;

- illumination and lighting conditions with particular regard to: specific task requirements; brightness; shadow; glare; contrast between objects and background; and colour;

- noise and auditory signals with particular regard to: effectiveness of attention gaining devices; interference with important communications; factors which cause annoyance or distraction;

- working position with particular regard to: postural stability; working clearances and accommodation for operator-size variability; seat design and operator discomfort;

- influence of the thermal environment and its potential impact on operator distraction and an operator's mental performance.

The following shortcomings were identified in the standard of ergonomics (these shortcomings were identified as Potential Active Failures as defined in Appendix 2):

◊ visual restrictions were identified as an underlying cause of accident potential in a number of installations. For example:

- ❖ In some installations, the safety of workmen engaged in bank activities was dependent on winder operators maintaining visual awareness of their movements. However, obstructions in the operator's field of vision resulted in workmen adopting safety critical locations where they were not visible to the operator; and

- ❖ glare from sunlight prevented operators from reading important displays such as dial gauges and ammeters in some control stations. A failure to cover holes in the roof of the control room was identified as the main cause of the problem.

◊ error potential was increased by the design of ammeter displays. Ammeters are a safety feature and indicate when excessive loads are applied to a winder rope. None of the ammeters examined were marked, coded or provided with supplementary warning lights to indicate when critical values had been reached. Safe operation was dependent on the operator remembering the critical values. Given a requirement at some mines for operators to operate different installations, which have different performance characteristics, error potential is significant. This is further enhanced by the training limitations outlined below; and

◊ ventilation arrangements in some control rooms were poor and the close proximity of hot electrical enclosures to the operating position was likely to influence the reliability of operator performance.

Additional controls

The following controls, designed to reduce the potential for winder operator error, were also identified;

- winder control room telephones linked with winder brakes to prevent operators using the telephone while the winder is in motion;

- training in safe working procedures covering the safety critical aspects of winder operation;

- winder room isolated from external noise sources which can distract operators;

- warning signs forbidding entry of unauthorised people into winder room.

- ventilation systems in winder rooms to control the generation of high ambient temperatures;

- regular inspections of winder control rooms include checks on temperature;

- the Minerals Act specifies a maximum working temperature above which workmen have the right to withdraw from the workplace;

- pre-use inspections undertaken by winder operatives to ensure that winders are in a safe condition to operate;

- notices warning operators of the maximum loads that can be hoisted.

The following shortcomings were identified

◊ at some mines, written procedures stipulated a requirement to display notices warning winder operators of the maximum loads that can be safely transported. The procedures were however not always complied with and the required notices were not displayed;

◊ warning signs forbidding entry of unauthorised people into hoist rooms were frequently ignored. It is not unusual for these areas to be used as meetings places or restrooms while winding operations were in progress. Operators were often distracted from their work by such activities;

◊ whilst most winder operators had been given formal training centre based training prior to being appointed, their training was often centred on a different type of winder or system of operation to that which they were employed to operate. This can lead to confusion and in moments of stress operators may revert to their original training;

◊ in many cases, winder operators are allowed to keep their licenses to operate winders indefinitely regardless of how infrequently or for how long it may have been since they last operated a winder. Very little refresher training is given and annual induction training does not include issues associated with small winder operation. There is a risk that operators will forget their original training and make mistakes;

◊ training limitations were implicated in a number of potentially unsafe actions identified during the studies. For example:

    ❖ a winder driver set a winder in motion while a workman was leaning against a drum;

    ❖ a driver was seen using a telephone while he was operating the winder;

    ❖ drivers were instructed that they should not communicate with people while they are operating winders, however, these instructions were regularly disregarded. On one occasion an driver allowed a group of people to enter the control room and then entered into lengthy discussions with them. During this period he continued to operate the winder.

◊ pre-use checks can only be reliably conducted if winder drivers are provided with the correct forms or documentation. Studies at the mines indicated that this was not always the case. For example, at one mine there had been a long-term shortage of the correct forms and the driver had been issued with a set for a scraper winch which did not include a number of critical checks that should have been made on the winder he was operating.

3.5.9 Falling objects

Physical barriers and protective measures

A range of physical measures designed to prevent or provide protection against the impact of falling objects were identified. These included:

- kickboards provided round shaft openings and at the edges of platforms where there is a risk of loose items being inadvertently kicked off and falling on people working below;
- ladders and stairways in shafts fenced off or screened from conveyance ways;
- canopies provided over man-riding conveyances;
- bank doors over vertical and steep incline shafts;
- ground and floors that slope away from shaft openings;
- straps available on banks and at shaft stations to secure loose loads;
- height/width control gates used on banks and at shaft stations to prevent overloaded conveyances from entering the shaft;
- provision of demarcated areas of safety and appropriate refuges where people can go for protection when activities are carried out where there is a risk of objects falling;
- lock-bell controls located where onsetters can operate them without placing themselves in a position where they are at risk from being stuck by falling objects;
- good visibility in loading box areas to prevent workmen over-loading conveyances;

The following shortcomings were identified:

◊ kick boards are not used systematically;

◊ in some shafts where people have to travel on ladders or stairways there is no effective separation from the conveyance way. Any items falling down the shaft could be deflected onto people travelling;

◊ while most shaft stations are provided with appropriately demarcated areas of safety and/or refuges, lock-bell controls on some vertical and steep incline shafts are located where operatives would be at risk from being hit by anything falling down the shaft; and

◊ visibility in some loading box areas is poor with the result that conveyances can be over-loaded. During transit it is not uncommon for lumps to fall off these conveyances and drop down the shaft where there is a risk of people being struck by them.

Procedures

The following procedural controls were identified:

- housekeeping arrangements aimed at removing loose objects which could drop and hit people working below;

- site safety inspections designed to remove potential falling objects, identify housekeeping limitations and initiate remedial action;
- procedures aimed at preventing the stacking of supplies and equipment close to open shafts; and
- safe working procedures produced to control the influence of activities where there is a particularly high risk of people being struck by falling objects. Safe working procedures were identified covering*:*
  - maintenance activities in headgear;
  - the importance of using protective canopies while riding in in conveyances;
  - activities undertaken on banks while people are working in shafts;
  - the use of bank doors;
  - loading of conveyances, particularly when loose loads are involved;
  - maintenance activities in shafts while other activities are taking place in the shaft or in the vicinity of shaft stations;
  - mechanised lifting and handling of loads on banks; and
  - routine inspections to ascertain the condition of the operating and retaining mechanisms on drop-sets and other safety devices where mechanical failure could result in people being hit by a collapse of the equipment.

The following shortcomings were identified:

◊ the standards of housekeeping and site safety inspections vary considerably across mines. In some cases mines demonstrate that very high standards can be achieved but in other cases standards are poor. The failure to remove rock fragments from platforms on steep incline ladders and loose debris from the proximity of shaft entrances have been identified as conditions of particular concern;

◊ the limits on the maximum number of people that can be carried in small conveyances was sometimes exceeded. This resulted in people travelling while standing on top of the protective canopies. As well as being at risk from falling from the conveyance, these people were also at risk from being hit by anything falling down the shaft;

◊ bank doors on some shafts were regularly left open while work was carried out in the shaft. While the main purpose of bank doors is to prevent uncontrolled entrance of conveyances into the shaft, they can also play an important in preventing both people and objects falling down the shaft;

◊ inconsistencies existed in the standard of safe working procedures. Some written procedures were of a high standard and were specific in detailing the hazards associated with a particular activity and the correct methods of work and precautions that should be adopted. Other procedures were however less detailed and specific and were open to varying degrees of interpretation;

◊ inconsistencies also existed in the coverage provided by proscribed safe working procedures. While some high risk activities had been adequately covered, others had been ignored;

◊ procedures covering the stacking of supplies and equipment close to open shafts are not always followed; and

◊ written procedures covering the mechanical lifting and handling of supplies and equipment on banks were often impractical. The potential for improvisation and the attendant risk of being hit by falling objects was considerable.

3.6. Design of shaft and station layouts

The design stage is where the most dramatic impact can be made on long term operational safety, and a review of all possible options is necessary to apply the most effective design in each case.

Consideration must be given not only to the effectiveness of the design but also to the health and safety aspects. Often only a little extra effort can reduce risks significantly.

There are several basic shaft and station layouts, which are shown generally on the attached sketches. These can be summarised as :

3.6.1 "over brow" design

The bank is a horizontal extension of the incline shaft, as shown diagrammatically in Fig 3.6.1. Cars must be pushed by hand over the brow into the incline while attached to the winding rope, and great care must be taken to avoid both physical damage to the rope and the development of a slack rope situation when a runaway car could cause rope damage or failure. Various safety devices such as the Marievale or "vula-vala" have been installed to assist in control of the cars.

This design is often used in situations where space is restricted, when the lower station is of similar layout to the bank ie a runaway car would exit straight onto the lower station. Other pertinent issues include:

- care must be taken to prevent cars being shunted directly into the shaft;
- a small deviation from proper operational standards can cause a serious incident; and
- the mine risk assessment team saw this as the most hazardous design.

3.6.2 "station dropset" design of station access

The station is mined in the hanging wall above the incline shaft (see Fig 3.6.2), and a steel set is lowered into the shaft when required to support the material cars as they are moved from the shaft onto the station. This layout is used on steeper inclines, and can of course also be used at the bank and at the lower station. Other pertinent issues include:

- the dropsets should be interlocked with the winder to avoid a shaft accident. On one installation, consideration is being given to providing underwind and overwind limits linked to each station dropset;
- the chance of a runaway car coming out onto the station is reduced;

- cars are pulled up from the bank into the shaft with the rope under tension; and
- a dead end can be provided in the shaft below the lower station.

3.6.3 “ramped” design of station access

The material cars are switched from the rail track in the shaft onto a short ramped section of track which is curved down to the station at the side of the shaft (see Fig 3.6.3). This design is used on shallower inclines, and can be applied to the bank and lower station as well as intermediate stations. Other pertinent issues include:

- the rail switch in the shaft can be set to the “straight through “ position, so reducing the chance of a runaway car coming out onto the station;
- cars are pulled up from the bank into the shaft with the rope under tension;
- a dead end can be provided in the shaft below the lower station;
- the chance of a car being shunted into the shaft is eliminated; and
- careful design is required of the ramped section onto the station.

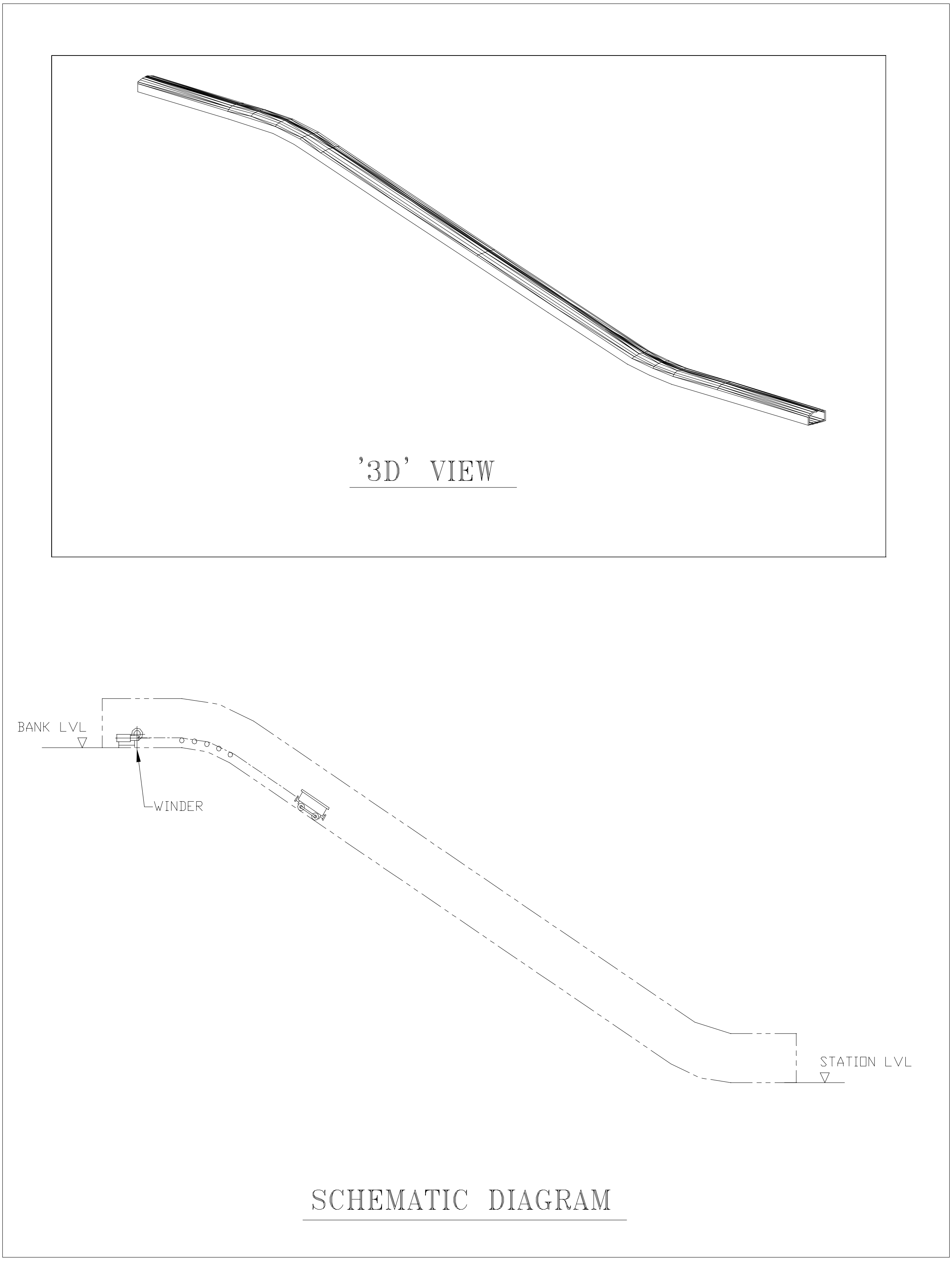
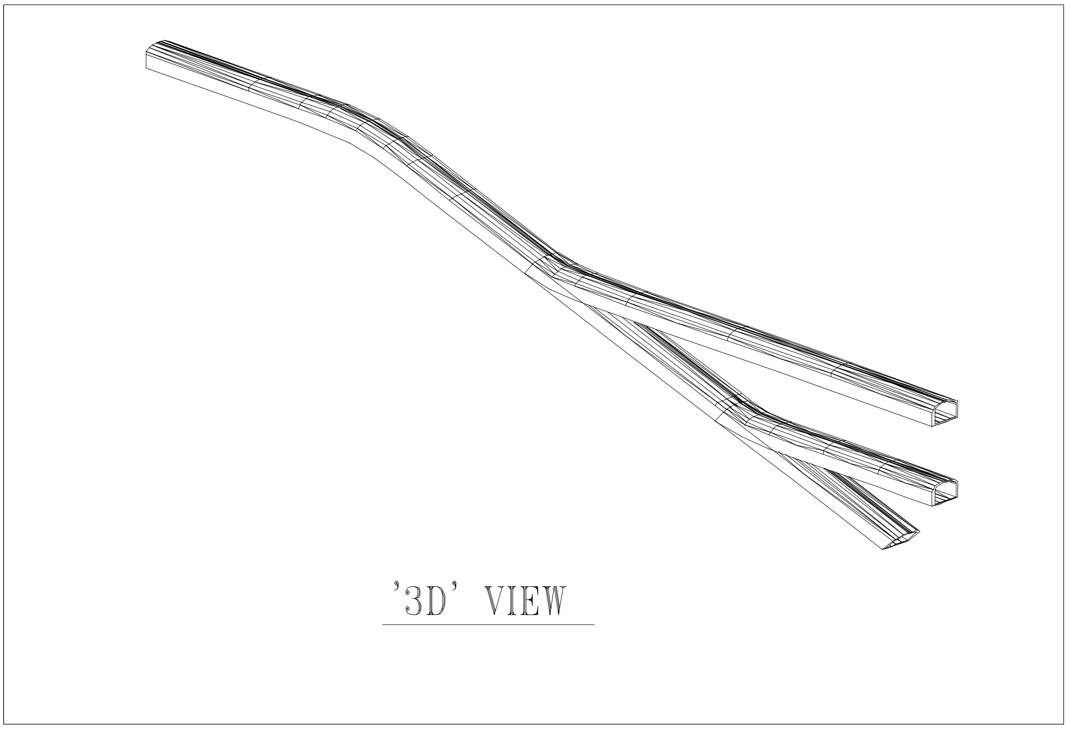


Fig 3.6.1: "Over-brow" shaft layout



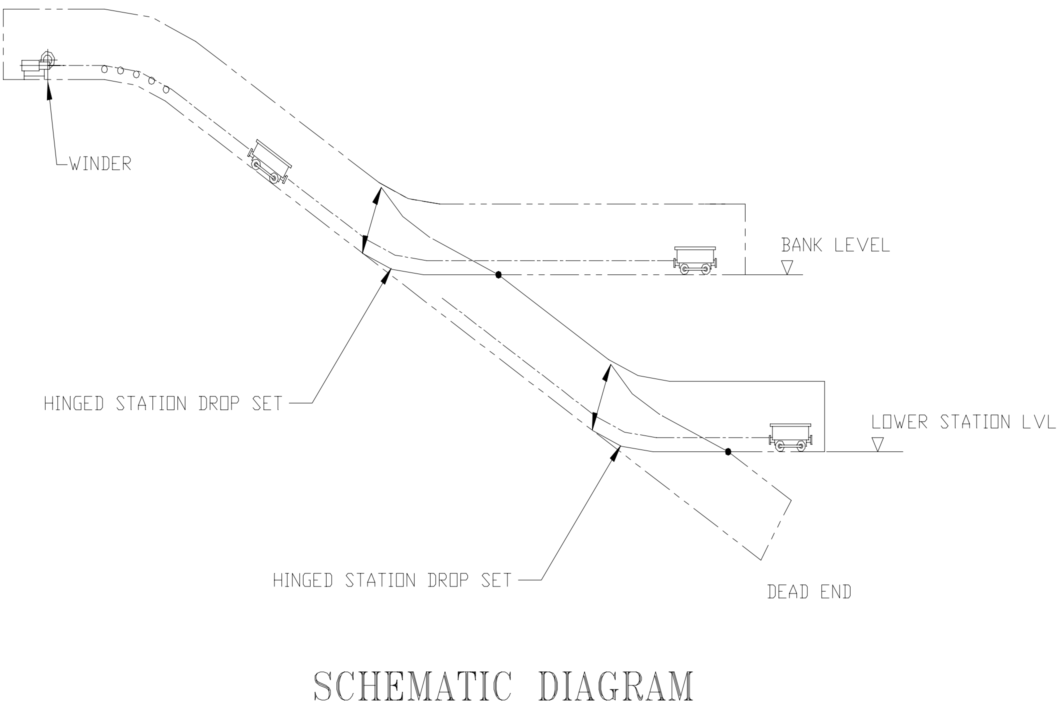


Figure 3.6.2: "Station drop set" shaft layout

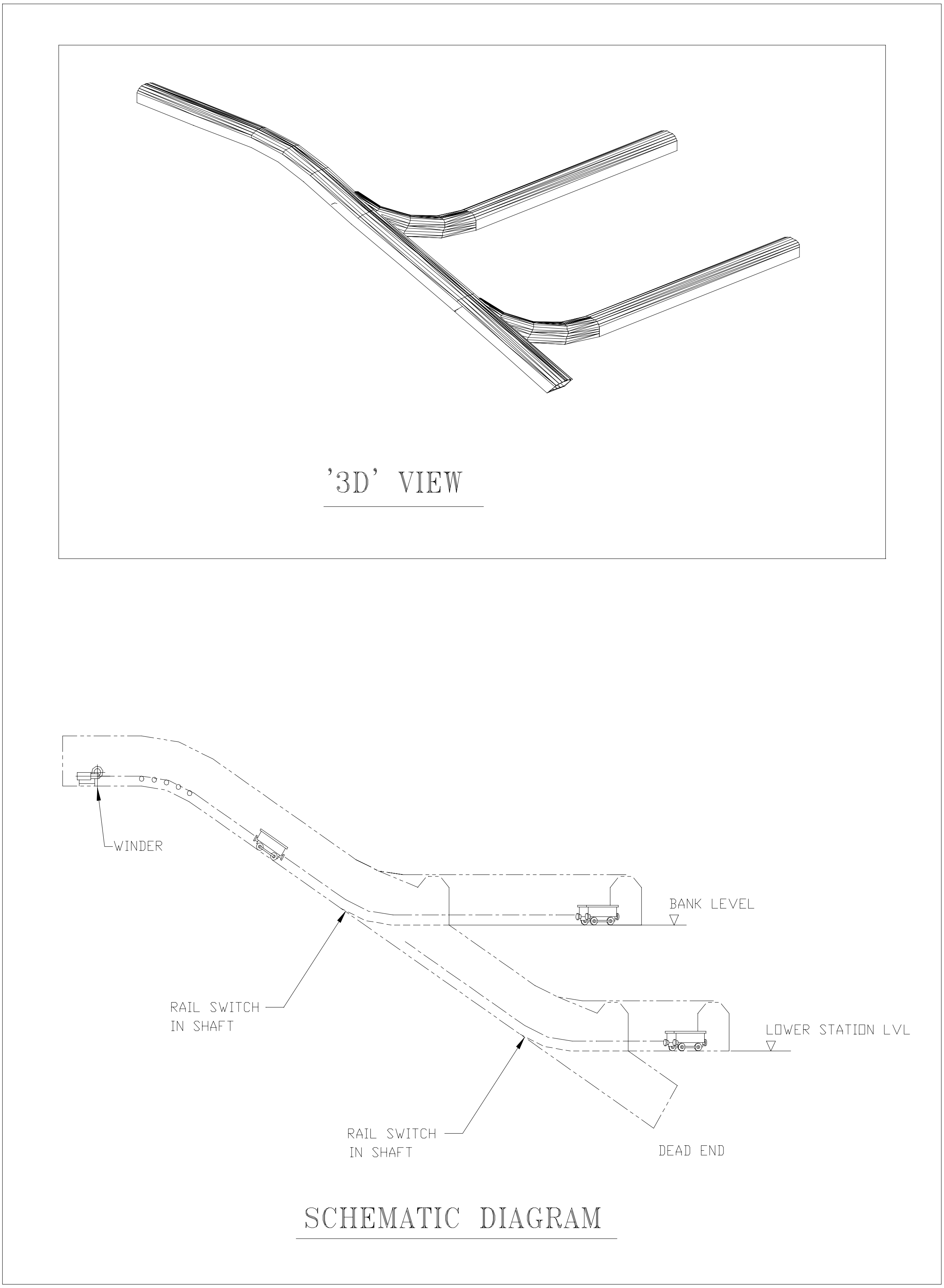


Figure 3.6.3: "Ramped access" shaft layout

3.6.4 Handling of material cars

Three different methods of handling material cars were noted:

- material cars attached to a pilot car or directly to the winding rope. The controls and shortcomings of this design have been fully reviewed in preceding sections;
- loading of material cars onto a large flatcar or "crocodile", which is attached to the winding rope; and
- confinement of the material cars inside a frame or bridle which is attached to the winding rope.

The latter two options are used on "heavy duty" installations, and have the benefit of eliminating all the hazards associated with coupling slings and pins for connection of material cars. They have the following shortcomings:

◊ they require more space in the shaft and on stations; and

◊ they require the use of larger winders to handle the increased loads.

4. Discussions and Conclusions

Although only a relatively small sample of small winder sites were studied during this project, it was apparent that a significant variation in terms of the design, operation and maintenance standards applied to small winder systems currently exists. During discussions with mine users and other interested parties (such as OEMs and the Inspectorate) the view that many small winders are not treated with the respect they deserve was often expressed. The project established that those small winders licensed for man winding tended to be well designed and maintained; however, the same cannot be said for many small unlicensed material winders. There appear to be several general factors that influence the quality of design, maintenance and operation of small winders. These are:

- **Mine size and large winder expertise.** The studies indicated that standards of installation, operation and maintenance tended to be higher on the larger mines where there was a culture of licensed winder operation. In such situations it is relatively easy for staff involved with “small” winders to seek advice from their “large winder” counterparts, and to use standards of design and operation that already exist; this comment is even more applicable where the standards originate from a central technical office. Staff on small mines do not have this facility.

- **Duty and application.** As is to be expected, winders that are important to mine operations are treated with more respect than others. However, an interesting comment from several sources was that the steeper an incline is, the more “dangerous” it is perceived to be and so the more attention it receives.

- **Nomenclature**. Winding plants on the mines, whether large or small, are variously referred to as “winders” or “hoists”. The term “winch” is added to the variety for small winding plant. Use of the words “hoist” and “winch” tends to give the impression that these are not really important enough to earn the title of “winder”.

  An attempt has been made to rationalise this terminology. Mesarovich (1991:13) suggested that the nomenclature should be based on the duty cycle, as is done for electric overhead travelling cranes, and proposed the following classification:

Class	Name	Duty
1	Hoist	light duties, works less than 4 hours per day, does not always have a full load
2	Winch	medium duties, works less than 8 hours per day
3	Winder	heavy duties, works continuously, always carries a full load

  This does however create problems in that a machine may be used on different duty cycles during its working life, and so may be classified differently at different times. The use of this system could also result in a small man winder being classed as a “winch” or “hoist” compared to a large “winder” being used for material. Standard nomenclature should be agreed by the users.

4.1. Application of Regulations to small winding plant

It was apparent from the review of the governing Regulations and from discussions with users that Regulations 16.94, 16.95.1 and 16.95.2 are unclear at best and confusing at worst, with the possibility of different interpretations of responsibility for appointment of competent persons and frequency of examinations.

In particular:

- it is necessary to cross-refer throughout Chapter 16 to establish which Regulations are not applicable; and

- several exclusions cover design features which should be applied as a matter of course.

Discussions with users, OEMs and the Inspectorate elicited the following further information:

- some Regulations which, at first sight, appear to be outside the norms for small winding plants are evidently being insisted upon by the Inspectorate; and

- other Regulations which are not applicable are being used voluntarily eg the "Government" Code of Signals.

The appointment of a person under Regulation 2.13.12 to be in charge of machinery can create confusion and so lead to a situation where neither the appointee nor the Engineer are clear as to their responsibilities. However, the trend towards the appointment of "Transportation Managers", responsible for all engineering and operational activities in their sphere of operation, should help alleviate this problem.

It is also evident that improved controls need to be in place on small winder systems. Although the winder Regulations are currently being re-written by a tripartite task team, enforcing such controls through prescriptive legislation may be too onerous, and indeed not practicable, due to the many different layouts and applications. In addition, a document is needed that will give guidance on current designs and applications of best practice.

4.2. Use of Risk Assessment

With the introduction of risk assessment in the industry in 1996 through the Mine Health and Safety Act, there is a move away from prescriptive legislation to a more goal setting regime. Each employer is responsible for assessing and responding to risk. Actions need to be taken to reduce risk, based on the specific nature of the hazards and the level of risk that are faced within an operation. No documentary or anecdotal evidence could be found at five of the six study sites to indicate that this had been completed. On one of the other mines studied, it was reported that a risk assessment had been done for the mine's main licensed winders and it was implied that this would also cover the small winders. In practice, such assessments are likely to be of little or no value in terms of identifying hazards or reducing the risk to health and safety that arise from small winders, unless the same standards and procedures are both applied and maintained with the same level of rigour and commitment usually afforded to main shaft winders. As pointed out above, applying large winder standards to small winders would in the vast majority of cases be too onerous and impractical.

Given the many different layouts and applications of small winder systems, it must be concluded that the most practical and effective approach to reducing the health and safety risks associated with small winder systems is via the use of mine/application specific risk assessments. However, the number of appropriate risk assessments available clearly demonstrates that since the requirements for risk assessment were introduced by the Mines Health and Safety Act limited progress has been made in this respect.

For a risk assessment based approach to accident reduction to be effective, the first requirement is that they are actually done. It is acknowledged that the legislative requirement to assess and respond to risks represented a significant challenge to the industry and hence it is likely to take a significant time to assess and respond to all of the risks being faced. However, the potential level of health and safety risks shown to be associated with small winder operations are such that they should now be addressed as a matter of priority. The need to allocate higher priorities in this respect should be reinforced by the DME by encouraging mines to increase the priority being given to conducting suitable and sufficient risk assessments on all of their small winder systems.

The level of improvement achieved by mines will ultimately be determined largely by the quality and suitability of the hazard identification and risk control processes they employ. The range of potential control limitations identified during the project, along with the documented examples of risk assessments given in Appendix 6, illustrate the level of detail likely to be required within a risk assessment in order to effectively address the significant hazards that currently exist.

As stated in the methodology section, the mine risk assessments facilitated by the project involved the following steps:

1. Identify potential hazards

2. Identify control currently in place

3. Identify control limitations

4. Assess the risk

5. Improve controls

The experience gained whilst conducting mine based studies leads to the conclusion that mine personnel have little or no difficulty in identifying potential hazards or the controls that should currently be in place. Adopting a systematic approach based either on a logical breakdown of the items of equipment in use or of the operations conducted will result in a comprehensive list of potential hazards being identified.

This report also identifies the significant potential hazards associated with small winder systems (for both vertical and incline applications) along with the typical control measures that were in place to reduce the risk of these hazards occurring. Hence, it may also be used to further ensure that significant potential hazards and relevant controls are not overlooked by mine assessment teams.

The principal key to effective risk reduction lies in the identification of control limitations and the implementation of improvements or additional controls required to reduce risk to a level that is low as reasonably practicable. The majority of control limitations identified during the project arose from shortcomings or problems in the areas discussed below.

4.3. Operating Procedures

At the majority of small winder installations studied there were significant shortcomings associated with written rules and standard procedures. In some cases written procedures were largely irrelevant or impractical as they had originally been produced for another winder at the mine (typically, a larger or licensed winder). In other cases mines had produced generic procedures to cover all their winders, but again, due to the differences across installations, these were either impractical or too general to be of value at the individual installations. Situations were also encountered where mines had no written procedures of their own available and were proposing to use procedures that had been produced by another mine.

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 or Codes of Practice 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. The risk assessment process is probably the most practical and effective way by which mines can achieve this goal. The hazards and control limitations identified during risk assessment provide a comprehensive indication of the situations and risks that such procedural controls need to address. It is important that the workforce is involved in the risk assessment and the subsequent development of procedures both to ensure practicality and encourage ownership.

4.4. Training

Once such effective operational procedures have been produced, they must be effectively communicated to the relevant members of the workforce. For such training to be effective, trainees should not only be instructed in the procedures to be followed. They 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. It may, in some cases, be impractical to produce detailed rules and operating procedures for all aspects of small winder operations. In these situations, the results of a comprehensive risk assessment exercise should be used as the basis for identifying training needs and setting training objectives.

4.5. Inspections, testing and examinations

There were a large number of different inspection and testing regimes in place at mines for unlicensed small winders. One of the reasons for this variation is the difficulty in establishing which Regulations apply to small winding plant, and the content and frequency of inspection tasks.

One of the major concerns by mines and during the user workshops was the lack of properly trained and competent staff, especially for rope examinations. On unlicensed operations, the rope inspections were carried out to differing standards (ranging from a completing a checklist to nothing more than a visual inspection that is signed in the log book) by a number of different classes of person (such as riggers and other 'multi-skilled' artisans). It was pointed out that many of these persons had not been fully trained in rope examination techniques or rope discard criteria, and as a result there was support for the use of relevant parts of SABS 0293 as an assessment and qualification standard for visual rope inspections.

It was also apparent that mines apply varying standards for the testing of brakes on unlicensed winders, most notably the thruster emergency brake on older single drum winders. The design of retrofit features to facilitate this, and the relevant procedures, should be considered.

The effectiveness of formal inspections at the mine (such as shaft examinations and safety officer's inspections) must also be questioned. Many of the shortcomings identified in the study, and reported in the previous chapter, should be identified by these inspections, and subsequent corrective action taken where necessary. These problems are brought about by either failing to inspect correctly and identify the shortcomings, or failing to take remedial action on the shortcomings once they are identified. It was pointed out that on many small winder installations maintenance time following a shaft examination where corrective action should be taken is very limited due to production pressures to return the shaft into operation.

4.6. Signalling systems

The use of the Government Code of Signals, as defined in the Minerals Act, is usually specified for unlicensed installations even though it does not have to apply. This leads directly to the possible use of abbreviated signals such as 'short bells' and 'open bells' by the winder operators, as ringing the full code is seen as being either too complex or too long winded for that small winder installation. It was also reported that there was also a lack of knowledge of the code of signals amongst the banksmen and onsetters.

On the mines, it is usual for banksmen and onsetters to follow a career progression that takes them from small unlicensed winders, to small licensed winders and then onto larger licensed winders. Mines recognise that trying to train operators in different signalling codes according to the type of winder could be confusing and lead to problems.

The question of standardising on a simple code of signals for small winders that addresses the above issues should be considered.

4.7. Winder design and application

Mine staff and OEMs noted that small winders are sometimes moved around a mine to be used in different applications. Often the original design parameters of the machine are not available, thus its suitability for the new application cannot be checked, and usually cognisance is only taken of rope speed and rope pull. Insufficient attention is given to other design considerations, such as slow braking and raise/lower discrimination for brake application, which are important safety considerations.

Winder manufacturers stated that different mines have different design standards, and that the quality of these standards varies considerably. There is a need for a basic design specification for small winding plant, so that the fundamental requirements can be defined and guidance given on other optional or desirable features which may be required in specific applications. The standardisation of nomenclature for "winders", as opposed to "winches" or "hoists", would be a useful spin-off from such a process.

It was noted that the manufacturers are continuing to improve designs in conjunction with users. However there is often a need to retrofit features of these new designs to older machines; the development of a basic specification would assist this process by defining retrofit priorities.

4.8. Design of incline shaft layouts

During the research, cognisance was taken of the various incline shaft layouts used on the mines. It was readily apparent that layout design can have a major influence on safety of operation as poor layouts can effectively introduce additional and unnecessary hazards. Hence, there is a need to evaluate the relative safety hazards and risks and take greater cognisance of them, even when fundamental design decisions are being made.

4.9. Summary

The vast majority of issues and control limitations identified by the project are not unique to small winder operations, rather they reflect many of the generic problems faced by the industry. The limitations associated with written procedures and problems of non-compliance with mine standards during this project are the same as many of those identified during project SIMRAC sponsored project GEN 213 “Reasons for non-compliance”. Similarly, the potential human errors identified are directly attributable to the same generic latent failures identified by projects OTH 202 “Investigation of the causes of transport and tramming accidents on mines other than coal, gold and platinum” and COL 516 “Investigate the causes of transport and tramming accidents on coal mines”.

The project has demonstrated how a simple subjective risk assessment process can be used to effectively identify and address the significant hazards and risks associated with small winder operation. To successfully achieve this, cognisance must be taken of the potential for human error to limit the reliability of both physical and procedural controls. The reports referenced above provide detailed insights into many of the limitations that should be considered. However, to promote technology transfer and encourage mines to conduct risk assessments that more effectively address the range of problems identified by the project, the checklist of potential control limitations given in Appendix 7 has been produced.

5. Recommendations

The findings of this project indicate that consideration should be given to the following recommendations:

1. The Regulations concerning small winding plant should be reviewed urgently in order to clarify the confusion that presently prevails.

2. A safety standard for the design, installation, operation, maintenance, inspection and testing of small winders, together with their peripheral activities, should be developed to act both as a technical guideline and as a source of reference for current best practice.

3. In addition to producing generic Codes of Practice for small winder systems, mines should also be encouraged to produce a detailed risk assessment for all small winder operations as a matter of priority.

4. When conducting risk assessments of small winders, mines should use the checklist of potential control limitations produced by the project to help ensure that cognisance is taken of the hazard potential arising from human error and design limitations.

5. Small winder risk assessments should be used as an integral part of the training process to assist in the definition of training needs and standards and to ensure that trainees are informed of the hazards and risks they face.

6. The relevant sections of SABS 0293 should be used as the basis for the certification of persons responsible for undertaking visual rope examinations.

5.1. Further Research and Development

This project, together with the previously completed SIMRAC projects OTH 202, GEN 213 and COL 516, has demonstrated both the need for and potential benefits in improved health and safety that could be derived by the whole of the South African mining industry by identifying human error potential and hence, increasing human reliability. It is therefore strongly recommended that further work should be undertaken to develop a process that can be used more widely by the industry.

The key objective of this work would be to widen access to the procedures used and to ensure that technology transfer is successful to a wide range of mine staff. The current approaches, whilst very effective, require skilled input, often from human factors specialists. The proposed intention would be to provide a suite of tools and procedures to identify potential control failures that can be readily used, understood and integrated with the various risk assessment processes used by mines.

6. References

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Appendix 1
Contracted Project Outputs

DEPARTMENT OF MINERALS AND ENERGY

PROPOSAL FOR A PROJECT TO BE FUNDED IN TERMS OF THE MINERALS ACT

- CONFIDENTIAL -

1. PROJECT SUMMARY

PROJECT TITLE :	RISK ANALYSIS AND ASSESSMENT OF VERTICAL AND INCLINE SMALL WINDER SYSTEMS AND PERIPHERAL ACTIVITIES
PROJECT LEADER :	P S MOSS
ORGANISATION :	IMC KNIGHT PIÉSOLD MINING (PTY) LTD
ADDRESS :	PO Box 221, Rivonia, 2128, South Africa TC Watermeyer Centre, Cnr Rivonia Boulevard & 10th Avenue, Rivonia
TELEPHONE :	(011) 806 7111 FAX : (011) 806 7100

PRIMARY OUTPUT :

A report containing an analysis of accidents and incidents and identifying critical problem areas associated with the design, maintenance and safe operation of small winders on mines along with recommendations for improvement.

HOW USED ? :

The analysis of past accidents and incidents, together with risk assessments of current practices, will highlight the need to review current mine practices and establish more effective codes of practice, and hence provide a firm basis for improved operation and maintenance of small winders.

BY WHOM ? :

All mining industry stakeholders, DME, SIMRAC, MRAC, manufacturers, suppliers and researchers.

CRITERIA FOR USE :

Recommendations must be practical, risk assessment based and take full account of the human factors involved

POTENTIAL IMPACT :

1. Improved safety performance
2. Identification of current best practices.
3. Improved utilisation of resources, productivity and maintenance
4. Improved user acceptance and raised awareness of the utility of pre-emptive risk analysis techniques.
5. Identification of factors to be considered when undertaking risk assessments

2. PROJECT DETAILS

2.1 PRIMARY OUTPUT:

A report and presentations giving the results of :

1. An analysis of accidents and incidents associated with small winders.
2. A risk assessment based identification of limitations in equipment specifications and current operational and maintenance procedures.
3. Identification of potential hazards, factors that may influence risk and recommended control measures.
4. Recommendations for improvement as necessary.

2.2 OTHER OUTPUTS :

1. Information for use in developing guidelines for risk assessments for small winders;
2. Information for use in improving codes of practice for operation and maintenance;
3. Increased awareness of small winder and peripheral problems on participating mines;
4. Increased awareness of the risk assessment process.

2.3 ENABLING OUTPUTS :

No	ENABLING OUTPUT	MILESTONE DATE*	MAN DAYS
1	Review past accidents and incidents related to small winders, identify sample of mines, agree this with SIMRAC and arrange access to collaborating mines.	4	26
2	Undertake observations and risk assessments at mines.	20	95
3	Analysis of mine assessments to identify generic hazards and develop generic recommendations.	24	35
4	Hold discussions with OEMs and appropriate specialist consultant, and report on outcome	26	20
5	Arrange user workshops at suitable venues to review and validate the findings to date, obtain further input and publicise the findings	32	22
6	Preparation of project final report and presentations as required by the SIMRAC Committee.	38	45

* Number of weeks of elapsed time from start date (presented cumulatively).

2.4 **METHODOLOGY** :

No. OF ENABLING OUTPUT	STEP No.	METHODOLOGY TO BE USED TO ACCOMPLISH THE ENABLING OUTPUT (INDICATE STEPS/ACTIVITIES)
1	1	Analysis of accident and incident information held on the SAMRASS data base in relation to small winders across all mines
	2	Presentation on findings to SIMGAP committee and/or working group with identification of and recommendation for appropriate mine sites, and agreement thereof with the committee.
	3	Agreement with participating mines.
2		Undertake the following work at each of the participating mines;
	1	Site observations, human error risk analysis and participative risk assessments covering small winder operation, maintenance and design.
	2	Analyse results of investigations on each mine.
3	1	Analyse mine information and develop generic recommendations
4	1	Discuss the generic results with OEMs and examine generic results using specialist insight into proposed legislative revision on small winders.
5	1	Hold user workshops at suitable venues near mines. These panels will aim to ensure the validity of the draft findings, and obtain further input, by involving knowledgeable mine officials in the development of the report.
	2	Provide a report on the outcome.
6	1	Preparation of project final report.
	2	Present and discuss the draft report with the SIMRAC Committee
	3	Update the draft report to final form

Appendix 2
Overview of Potential Human Error Audit

Overview of Potential Human Error Audit

Although it is widely recognised that human error is implicated in the vast majority of mining accidents, the reduction of error potential has received relatively little systematic attention as an approach to accident prevention. To this end, investigations carried out in SIMRAC projects OTH 202 and COL 506 provided a detailed and systematic knowledge of the factors likely to predispose human error in transport and tramming activities across the full range of mining operations. The investigation and analysis techniques used were part of the IMC behavioural safety system known as 'BeSafe' and these methods have been adapted to investigate the potential for human error in the design and operation of small winder installations.

The IMC BeSafe System was originally developed within the framework of the European Coal and Steel Communities Ergonomics Action Programme and was produced in response to reports from the UK Health and Safety Executive identifying that over 90% of accidents involve an element of human error. The system has been designed and further developed to identify the potential for human error within existing operations thereby:

- Releasing the investigation from working exclusively on past accident records; and
- Establishing the factors that are likely to increase error potential which are beyond the responsibility of the individuals concerned.

The IMC BeSafe System incorporates a module referred to as the Potential Human Error Audit which provides a method of examining human error potential through the identification of *Active Failures.*

Active Failures: These are errors made by operators and maintenance staff i.e. those with hands-on control of the system/equipment. They occur immediately prior to the accident event and are often seen as the "immediate cause". *Active Failures* are those errors which traditionally have been described as human error - driver error and pilot error being typical examples.

The definition of *Active Failures* given above indicates that they occur at the interface of the man and his equipment, machine, system, etc. Therefore, the traditional ergonomic man-machine system, as shown in Figure A2.1 represents an ideal starting point for the identification of *Active Failures*.

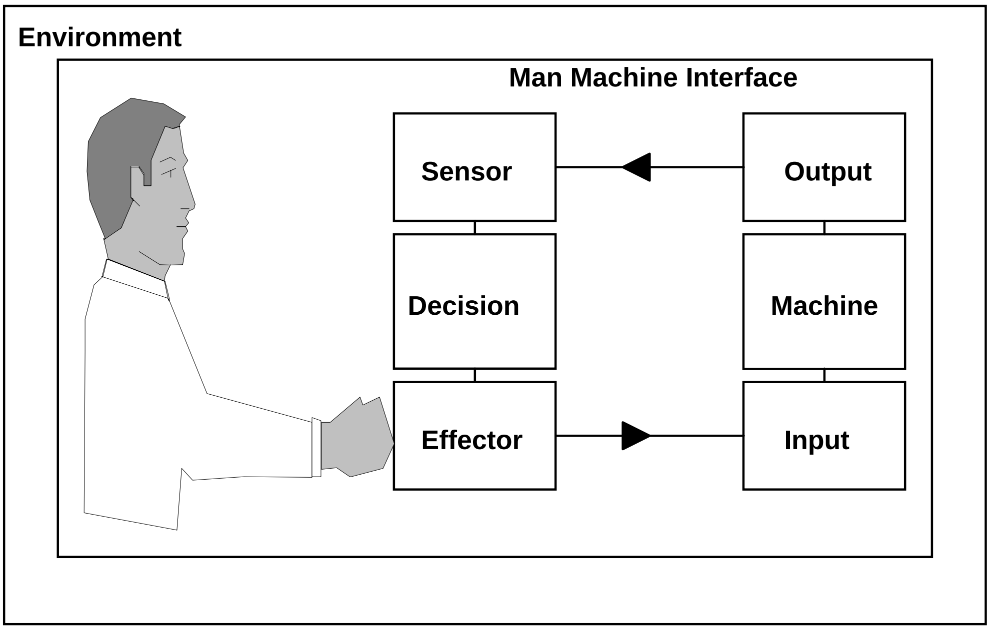

Figure A2.1 Man-Machine System

In this diagram it is evident that the operator receives information from the machine about the state of the operation, for example, whether the machine is doing what he wants it to, whether it is in the correct position, etc. He uses this information in order to make a decision as to whether he needs to change the operation of the machine in any way, and if so, to take the appropriate control action. The system applies to any activity with the man receiving and processing information and then acting upon it. The system works therefore as two superimposed feedback loops, the man providing the feedback to the machine and the machine to the man. If the system is to work safely and efficiently these two loops must be working effectively.

If the above man-machine system is re-drawn to concentrate on the man's role it is possible to create a simple representation of the human operator control function which can be applied to any working situation, as shown below in Figure A2.2.

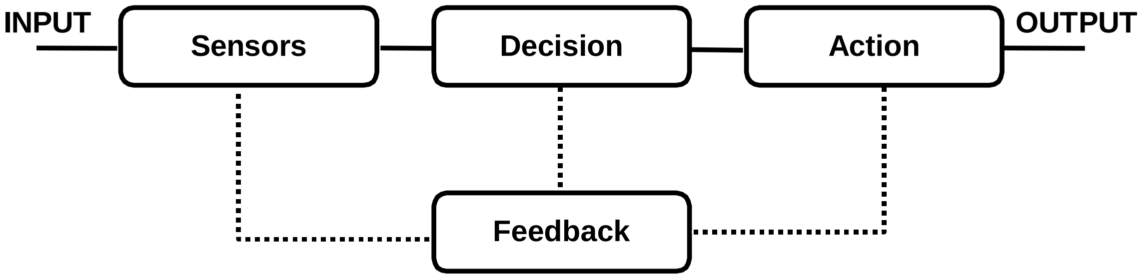

Figure A2.2 Human Operator Control Function

Figure A2.2 shows that, in the context of human error potential, there are four basic elements which can denigrate the safety and efficiency of an operation:

Information input

The information input to the sensors i.e. vision, hearing, touch, may be insufficient. The information source may be obscured, the correct information may not be available when the operator needs it, it may not be presented accurately enough, or too accurately, thereby causing confusion. Sight and hearing are the two senses most commonly used.

Decision

Good quality information needs to be received in order to enable a reliable decision to be made. If the information is inadequate or confusing, then the reliability of the decision is likely to suffer. Similarly, the information received often needs to be compared with the operator's mental picture of what he is trying to achieve. If there are incompatibilities, then there is an increased probability of error. If the decision is based on some form of operating rule, the quality of the decision is influenced by whether the operator knows the rule, whether he remembers it and whether the information is presented in a reasonable way.

Output

The successful completion of any task depends on the undertaking of output actions. Users commonly interface with machinery by operation of controls. Errors are likely to result if the operator is unable to reach a control, if he is unable to activate it accurately enough, or if a series of similar controls are placed close together, thereby causing confusion and activation of the wrong control. In addition to operating controls, workmen may have to action decisions by giving verbal or written instructions to others, or by performing other physical tasks.

Feedback

The feedback element concerns the question of how an operator knows when he has completed a task. Operators rely on two forms of feedback. Internal feedback occurs through a series of sensors in the body which ensure that, for example, they know, where their limbs are without having to look at them. These feedback sensors are crucial to safe operation, but it can be assumed, under normal circumstances with healthy individuals, that they function effectively. External feedback concerns any information about the change to the system which comes from outside the operator. This can be, for example, direct visual information [you see a conveyance or winder drum start to slow down after you've applied the brake] or "artificial" information presented by a dial or computer screen. In the latter case the operator would see the reading begin to fall on a speedometer as he applies the brake. External feedback can, therefore, be regarded as a special form of input.

External Influences

The operator control functions described above should not be considered in isolation. It is also essential to take cognisance of the wide range of external factors that may influence operator performance significantly. Figure A2.3 shows the spheres of external influence that should be considered.

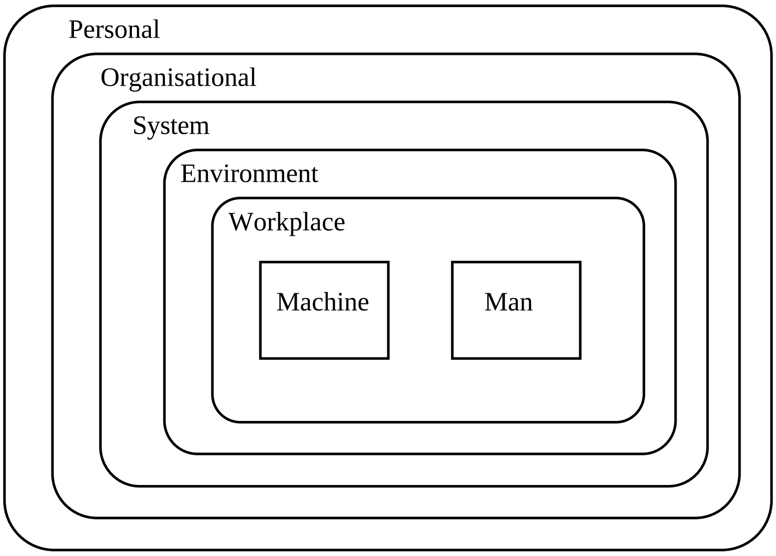

Figure A2.3 Spheres of External Influence

The central area within Figure A2.3 represents the traditional man-machine system, but it is shrouded by clearly defined, though complex, spheres of influence. These include:

- **Environment** which includes working headroom, air temperature, humidity, presence of dust or noise, etc.

- **System** which addresses interactions with other interdependent equipment or processes.

- **Organisational issues** which include training, communications, supervision, management style, etc.

- **Personal** which refers to the difficulties that people bring to the job. All people are different both mentally and physically. There are behavioural problems and different attitudes to safety to contend with.

These spheres of influence can have both a direct and indirect influence on the efficiency of the man-machine system and therefore can contain factors that are likely to predispose error potential i.e. *Active Failures*.

A complete and systematic working framework for identifying the potential for human error using the operator control function involves the following five steps:

1. All the primary elements in the task or operation under investigation should be listed.

2. All the safety rules associated with the operation of each task element should be listed, and all the decisions which the operator has to make during the completion of the element should be identified.

3. For each decision, all the information requirements to enable the decision to be made reliably should be identified.

4. All the actions relating to each decision should be listed. For each decision, all the physical requirements to enable the actions to be practically implemented reliably, should be identified.

5. For each task element a note should be made of the feedback required to enable the operator to know that he has successfully completed an operation.

When using this approach, the volume of information available and the number of decisions and actions made, even during the performance of relatively simple tasks, can be enormous. However, it is possible to rationalise this approach and produce a series comprehensive checklists which cover the main issues that need to be considered. These checklists are designed to act as aides-memoir to ensure that trained users of the IMC BeSafe system thoroughly address the potential for *Active Failures* resulting from:

- Visual input errors
- Auditory input errors
- Control operating output errors
- Verbal output errors
- Written output errors
- Other physical output errors

An extract from the control operating error checklist is shown below in Figure A2.4.

The Potential Human Error
What could happen if:
1. Control operated too early or too late? 2. The adjacent control was accidentally operated? 3. The control was inadvertently operated in the wrong direction? 4. The control was not operated at all? 5. .... 6. ....
Potential Causes of the Error
Which of the following could increase the likelihood of the error?
7. Poor control positioning-out of easy reach 8. Poor control positioning-not easily seen 9. Poor labelling 10. Operating forces too stiff 11. Control is too sensitive 12. Stereotype wrong 13. .... 14. ....

Figure A2.4 Aide Memoire Checklist for Control Operating Errors

These checklists are structured to raise two fundamental questions.

What could go wrong or what could happen if?

What could cause the error or increase the likelihood of the error?

A list of points are provided under each question to prompt careful thinking about the sort of errors that can occur, the "what could go wrong elements" and then to consider the potential causes of these input or output errors. By following this process it is then possible to consider the primary routes to error reduction by, for example:

- Design changes to equipment and the local environment.
- Changes to codes and rules, safe work procedures, etc.

- Improved training/education.
- Improvements in the effectiveness and commitment of management.
- Improvements in the effectiveness and commitment of supervisory staff.
- Changes to work organisation.

Appendix 3
Summary of comments from the User workshops

Summary of comments from User workshops

Topic	Comment from Users
Attitude	• "nobody wants to take ownership of small winders" • most small winder incidents not reported • perception that shallower inclines are treated with less respect than steeper or vertical • agreed that not conforming to standards is a major cause of incidents/accidents • some mines licence all small material winders under 16.2
Management	• Mine Overseers are often given responsibility over small winding plant as per Regulation 2.13.12, although this does not absolve the Engineer. Also, the MO's appointment letter from the Inspector often says that control should be exercised using a Code of Practice approved by the Engineer; however, the Engineer does not always know of the appointment of the MO and so does not provide a Code of Practice • English is the official language, but not readily understood by all staff involved with small winders • the point was made that Managers remain responsible for safe conditions on winding plant even when this has recently been examined by an Inspector
Regulatory	• present Mining Regulations currently being rewritten by various task teams • noted that the power rating for small winders (ref Regulation 16.94) was raised from 100kW to 250kW in 1988 • a recent court case indicated that an unlicenced driver could not operate a small winder when winding men during shaft exam/sinking
Procedures	• company takeovers cause confusion re application of generic procedures • some confusion caused when procedures are imported from another mine without being reviewed and amended as necessary • recognised that procedures need to be specific to the installation, and not generic

Summary of comments from User workshops (contd)

Topic	Comment from Users
Staffing	• many mines use rigger/ropemen but there is a move towards using multi-skilled fitters • concern expressed re low artisan skill level and move towards modular training as opposed to traditional apprenticeships • MQA developing standards for the industry • artisans not familiar with modern technology
Training	• concern expressed that central training of operators may teach different procedures to those used “on the job” – eg bells • adequate period of on the job familiarisation required for drivers and onsetters
Design	• OEMs will supply what you ask for, and come in with lowest price to get the job • MD1 form provides a good guideline for features that can be considered for small winder installations • good practice when cooling water columns are used as a brattice between incline shaft and ladderway • problem with location of rope rollers in shaft – should be as high as possible out of mud etc but then are damaged by cars • smaller safety drop rails in shaft should be interlocked with winder eg to trip winder if they are not put in place properly • slack rope devices cannot be applied to service inclines • agreed that the “overbrow” station design is the most hazardous, and this is usually accompanied by the track coming straight out onto the station at shaft bottom • Regulation 18.8.4.1 requires effective safety devices • the emergency brake should not be applied automatically when the controller is put into neutral: drivers have been found to select neutral and use the emergency brake to avoid using the awkward footbrake • underwinds trips desirable but difficult to use in incline shafts

Summary of comments from User workshops (contd)

Topic	Comment from Users
Signalling systems	• most inclines do not have lock bell systems • "Government" Code of Signals for licensed winders is displayed and referred to in procedures, but not always used: drivers and onsetters develop and use their own code until there is a problem • is this "Government Code" too complicated for small winders? However, small winder staff have a career progression up to licensed winders and so confusion must be avoided • users should check that a "lock bell" system is correctly designed and installed
Ropes	• noted that small winders on the diamond mines use crosby clamps and do not splice the rope • support for regular front end cuts • noted that, in a recent court case, Regulation 16.33 (rope not to be used if breaking strength less than 9/10 of that when new) had been held to apply to unlicensed winders. This also implied the need for an initial rope test certificate for use as a benchmark • riggers (as distinct from rigger/ropemen) do not always know what to look for when examining ropes. There was support for the use of relevant parts of SABS 0293 as an assessment and qualification standard for visual rope examination
Operations	• for unlicensed winders, a procedure should be put in place to recover persons from the shaft if power was lost during shaft exam • cellphones banned from footplates as they could distract the driver and also interfere with winder control systems • problems occur with slack rope on spillage winches due to spillage being allowed to build up below the lower station • procedure should be developed to specify material that can be hand carried while using shaft ladderways • bellmen are often involved in illegal man riding on unlicenced winders

Summary of comments from User workshops (contd)

Topic	Comment from Users
Material cars	• care must be taken such that car sizes are correctly related to the "vula-vala" device used on "over-brow" incline shaft layouts • operators do not know the masses of cars being handled • cars are sometimes locked so mass of contents cannot be assessed • there is a problem with standardisation of couplings • use of bridle noted for containing material cars during movement in incline shafts
Maintenance	• sheave maintenance not as critical on small winders as it is on larger installations, due to lower rope speeds • staff should use properly designed and tested safety harnesses for shaft work • noted that it is difficult for staff to have proper access to inspect inclined shafts closely
Inspection	• support for a third party check and annual inspection of brake components on larger installations • steel used for brake components may not be of high enough quality to give satisfactory NDT result • initial NDT test during manufacture is essential to provide a "thumbprint" for future reference

Appendix 4
Summary of OEM discussions

Summary of OEM discussions

Functional area	Topic	Comment
General	mine’s attitude towards "small winders"	strong Head Office control has generally disappeared and this has tended to lower standards
		use the term "winder" in preference to "winch" as the latter creates the perception of being of lesser importance
		to contain costs winders are frequently ordered without essential spares
		in regard to safety issues, management needs to view "small winders" in the same light as winders having a winding permit
		"winch" as opposed to "winder" is probably only justified on installations where all winding operations are carried out in the full view of the driver
	Specification	tender enquiries frequently lack adequate specification
		no clear standards
		there are no clear guidelines or requirements for the total small winder installation
		lack of specifications by users is not conductive to ensuring a quality product
		stakeholders often hold conflicting views especially where mines are under economic pressure
		a specification defining minimum standards would be desirable
		low price is usually the determining factor in tender adjudication

Summary of OEM discussions (contd)

Functional area	Topic	Comment
General (contd)	re-use of winders	winders are usually re-used in different applications for which they may not be suited; suitability includes factors such as braking and control characteristics as well as power and rope pull
		each application requires study to ensure that the winder is not used beyond its capability
		the above problem may be alleviated if all winders are provided with nameplates giving the salient performance criteria
		to prevent mismatching all winder parts, including electrical cubicles, should have a brass nameplate for clear identification
		historical over-design has ensured a long life for winder components
Winder design	brakes	thermal rating is often inadequate to stop the winder with the maximum out of balance load descending at the rated winder full speed
		the coupling brake is only suitable as a parking brake. Its thermal rating is inadequate to retard the winder under severe braking conditions
		concern expressed about the footbrake systems where there is no effective backup in the event of failure (eg dynamic braking)
		new winders being designed with higher capacity brakes
	brake control	equip winders with proportional brake control and positional quick drop features for rapid application of braking torque
		retardation control should be provided for rope speeds of 2 m/s and higher
		a low cost digital version of the ESCORT type brake control system is used on very small winders. Standard ESCORT controllers are used on larger winders.

Summary of OEM discussions (contd)

Functional area	Topic	Comment
Winder design (contd)	braking considerations in incline shafts	acceleration and retardation rates to be controlled and limited to prevent slack rope conditions.
	brakes for single drum winders	single drum winders to have two fully rated brakes each capable of holding 200% of maximum out-of-balance load
		"raise/lower" discrimination on brake controls to provide means of adjusting the "quick drop" (initial brake application torque) to prevent excessive rates of retardation when raising in a vertical shaft, and to prevent the conveyance from overrunning the rope on an incline
		the winder must have sufficient inertia to limit the natural acceleration/deceleration values to less than 2,2 m/s^2
	drive systems	in the absence of dynamic braking the mechanical brake is frequently overheated when used to achieve speed control with overhauling loads -- this leads to severe brake fade that could have serious consequences in the event of an emergency stop
		drive to provide torque in all situations, to avoid "free wheeling" and "driving through the brakes" to effect speed control ---- over- heating and brake fade is a serious side effect creating a potentially hazardous situation
		four quadrant drive control is essential to provide adequate speed control. This avoids the need for "free wheeling" or "driving through the brakes" to effect speed control.
		drive control systems are being upgraded to incorporate dynamic braking and modern thyristor switched rotor resistance to provide enhanced speed control

Summary of OEM discussions (contd)

Functional area	Topic	Comment
Winder design (contd)	drive systems (contd)	"economies of scale" have contained costs of modern control systems
		AC slipring induction motors are used for drives up to 150 kW. torque control is effected by employing thyristor switching to regulate the stator voltage supply and rotor resistance
		above about 150 kW, thyristor converter fed DC motor drives are generally more economical, provide excellent speed control, and are more efficient.
		drive motors should have a peak power rating of 200 % above the peak demand
	rope life and performance	
	• drum sizing	premature rope wear due to drum/rope diameter ratio often being too small
	• rope coiling	rope coiling sleeves should be fitted; poor practice to use the bottom layer to promote good coiling
	• brake control	high retardation rates can cause excessive load cycling and even slack rope
	• rope terminations	wedge type capels not recommended for use on inclines
		Crosby clips are very often incorrectly installed
	• rope selection	not always correct – should use Lang's lay ropes on inclines

Summary of OEM discussions (contd)

Functional area	Topic	Comment
Design of shaft system	signalling and interlocks	winders to have bell/brake interlock, single ring for materials and rock/men/material changeover sequence interlocking as appropriate
		station drop-set interlocking with enforced creep and limiting of rope paid out on incline shafts
		positional and directional interlocking required for the Marievale type “vula-vala” device
	derailment monitoring	properly designed Marshall’s devices to be installed
	winder layout	provision for over-wind travel is often inadequate
		often the shaft layout is done with insufficient attention to required fleeting angles, and “on-site” appliances to correct this often damage the rope further

Overview of comments by OEMs (contd)

Functional area	Topic	Comment
Maintenance - equipment	winders	the large number of small winders (upwards of 5000) is an aging asset standards variable, often less than adequate. A large proportion of units require attention in order to fully comply with performance requirements maintenance of winders on vertical shafts is generally better than winders on incline shafts --- different mind set it is suggested that mines enter into maintenance contracts with OEMs to inspect winders twice a year and to do the necessary maintenance small winders are often not equipped with a driver's ammeter and there is no procedure for testing the brakes economic and production pressures mean that required work is often not done
	ropes	shaft rollers not maintained to standard back ends not pulled in as often as necessary sheave maintenance is lacking - grooves are not measured or regularly machined front ends not cut regularly lubrication often poor

Summary of OEM discussions (contd)

Functional area	Topic	Comment
Maintenance - staffing	general	supervisors often have too many other duties to perform
		administrative overload of often inexperienced supervisory staff
		mines frequently rotate staff often removing knowledgeable people and replacing them with inexperienced staff
	training	staff shortages and low skill level especially at artisan grade could perhaps be overcome by training semi skilled staff to do specific jobs
		OEMs should provide courses for maintenance personnel
	ropes	lack of skill in handling ropes
		most, but not all, riggers generally keen and conscientious
		insufficient qualified riggers available
		use of multi-skilled tradesmen is increasing. On the larger mines training is good, but there are no criteria that can be used for smaller mines
		multi-skilled staff do attend OEM training courses
		the use of relevant sections of SABS 0293 for certification of riggers doing visual rope inspections is supported
Over inspection	over inspection and audit	an audit service is provided by OEMs but mines generally only use it on a breakdown basis
		noted that Safety Officers are now becoming much more involved
		listed shortcomings are not acted upon
Operational	drivers	training possibly inadequate

Summary of OEM discussions (contd)

Functional area	Topic	Comment
Regulatory	requirements too loose	enforce front end cut every 6 months enforce regular inspection of whole length of rope consider development of a Code of Practice for small winders

Appendix 5
Summary of Engineering assessment findings

Summary of Engineering risk assessment findings

Equipment area	Control	Significant shortcomings noted	Comment
Winder general	protection around machinery area	no demarcation of machinery area	provide handrails and demarcation
	guards	no guards on chain drives eg to indicator	provide guards
	availability of spares and service	one mine experienced problems	consider replacing problem components
Winding rope	visual examination	a short length of rope above the splice was covered by a plastic pipe sleeve to prevent abrasion of the rope	ensure that the full length of rope is open for inspection
		on a stage winder the sections of rope around the stage sheaves are not easily inspected	consider making guards easily removable
		shortage of staff to undertake inspections	review work process and manning needs
	measurement and inspection	not used in some installations	consider need for this control
	magnetic rope testing	not used in some installations	consider need for this control
			frequency of test not the same
	front end cut and load test	not used in some installations	consider need for this control
			frequency of test not the same
	proper design of installation to promote good coiling	poor coiling needed constant attention from engineering staff	investigate use of deflecting sheave to improve coiling

Summary of Engineering risk assessment findings (contd)

Equipment area	Control	Significant shortcomings noted	Comment
Braking system	design of links and pins	no provision to lubricate pins	pins showing signs of wear in heavy use application design modification required
	repair and maintenance	brake screwdown post poorly repaired	maintain engineering standards
	inspection of links and pins	unable to easily remove pins for inspection (especially the lower caliper pins) NDT not used on some installations	future designs must facilitate removal and improve access to this area consider use of NDT procedures
Braking system (contd)	testing of main brake by driver	not tested against specified ammeter reading tested using conveyance load in shaft	ensure that ammeter is visible to driver, specify reading and test procedure
	testing of emergency brake by electrician	not tested	specify and follow procedure
Conveyances			
attachments	visual inspection	not always done by trained staff	review work practices
	NDT	not used in some installations	consider need for this control
	proper design of attachment components	some attachment pins are of unknown design and manufacture	ensure proper design and manufacture
	spare attachment sets available	spare sets not always readily available	provide spare attachment sets

Summary of Engineering risk assessment findings (contd)

Equipment area	Control	Significant shortcomings noted	Comment
Conveyances (contd)			
structure	visual inspection	some material cars are not inspected before use to ensure suitability for use on incline	improve inspection procedures
		not always done by trained staff	review work practices
	proper design	some material cars are not designed for use on incline	consider standardising on car and coupling design
	safety door provided at rear of transporter conveyance	door easily damaged during loading/unloading of material cars	review design and maintenance needs
load and safety slings	regular inspection	not always over-inspected by engineering staff	review work practice
	change slings regularly	service life not always monitored and recorded	institute management system
	spare slings available	spare slings not always available	ensure spare slings available
	proper sling attachment points	car couplings are often used to attach safety slings. Non-standard couplings can prevent safe sling attachment	standardise sling attachment points
safety sprag	Blair device provided	may not function properly due to damage and poor maintenance	ensure proper maintenance and check operation

Summary of Engineering risk assessment findings (contd)

Equipment area	Control	Significant shortcomings noted	Comment
Safety trips and interlocks	visual	does not check functionality	functional test recommended
	functional test	not always done	ensure proper test consider over-inspection
	necessary devices provided and in working order	devices fitted additional to legal requirements not operational	consider repairing or removing non-functioning devices
		some devices considered necessary not provided or operational	ensure proper installation and operation
Electrical equipment incl signaling systems	proper design and installation	on some systems it was possible to instruct the driver to move the conveyance when located on another station	review design and installation of lock bell system consider installation of bell/brake interlock
		electrical devices on sinking stage subject to water ingress and corrosion	review design and installation
Stations and station equipment	proper design and layout	some dropset support steelwork could be damaged by overloaded cars	check design of dropset layout, review loading controls
		slack rope sometimes occurs when conveyance on dropsets	check design of dropset layout to avoid slack rope as far as possible
	provision of safety drop rails	not always properly installed or maintained	ensure correct installation and maintenance
	safety devices to be operated from a safe location	safety devices were sometimes operated from an unsafe location	review designs

Summary of Engineering risk assessment findings (contd)

Equipment area	Control	Significant shortcomings noted	Comment
Stations and station equipment (contd)	Proper illumination	some stations were poorly illuminated	provide illumination to Industry standards
	Design of station excavation	at some shaft bottom stations a runaway car would exit onto the station	excavation could be extended to provide a “dead-end” at shaft bottom
		some layouts permit slack rope when car being moved into shaft	initial layouts should avoid this feature
Shaft equipment	regular inspection and maintenance	not always sufficient time allocated for this activity	review shaft schedules and work practice
	properly installed shaft ladderway	some travelling ways require improvement	review design and installation
	safety devices such as safety drop sets	non-operational or poorly installed	check installation and maintenance

Appendix 6
Mine risk assessments

Incline material winder

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by car or material, due to:				
rope failure			6	
	safety drop rails (when working on station)	could throw cars onto station and not into shaft		consider moving the safety drop rail further up towards the shaft
				make sure that safety drop rail sits on station side of track
	rail switches in shaft normally in “straight through” position	-		operation must be checked daily
	“Blair” spragging device on hopper	possible jammed actuating cable		check daily
	protection rails on 90L station	people could stand in danger area		procedure/signage required
				install on 98L and 104L stations
	daily and weekly rope examinations	visual only		consider implementing NDT
	rope strength testing	-		-
	driver training	-		-
	rope lubrication	-		-
	maximum load – procedure and signage	signs old and illegible in places		new signs required
	station layout on 90L ensures that cars are pulled up into the shaft, avoiding slack rope	-		-
	slow braking on winder in overspeed trip situation	-		-

Incline material winder (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by car or material, due to: (contd)				
failure of car coupling, drawbar or slings			12	
	safety drop rails (when working on station)	could throw cars onto station and not into shaft		consider moving the safety drop rail further up towards the shaft
				ensure that safety drop rail sits on station side of track
	protection rails on 90l station	people could stand in danger area		procedure/signage required
				install on 98l and 104l
	purchase of certificated slings, regular examination and replacement	-		-
	maximum load – procedure and signage	signs old and illegible in places		new signs required
	properly designed safety slings and shackles, procedure for use	-		-
	solid drawbars on material cars	not fitted to all cars		train loading personnel on surface
		cannot easily check if drawbars are fitted		mark cars that do not have solid drawbars
		material cars pre-loaded on surface		implement programme to fit solid drawbars to all cars
	specially designed hopper drawbar pins	only one set in use		provide a spare set
				NDT test
	procedure and on – job training for dcoupling material cars	-		-
failure of winch brake			6	
	fail-safe main and emergency brake	-		-
	daily and weekly inspections			

Incline material winder (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by car or material, due to: (contd) unexpected movement of cars on stations	lock bell system provided proper bellman/driver training	-	4	bell/brake interlock being installed
unauthorised personnel gaining access to controlled areas	barricades on 90l station proper supervision proper walkways provided	unauthorised access to station area supervision not always present	9	provide procedure and signage for station area install barricades on 98l and 104l include station activities in induction training
hand tramming operations on 98L and 104L stations	visual check and warning to nearby personnel	area not properly controlled poor operation of car sprags	8	demarcate area with signs fit warning lights which operate when tramming improve communication with personnel provide proper sprags and spragging procedure

Incline material winder (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by car or material due to derailment caused by: poor track conditions	regular track inspection and maintenance	not enough time available – need 6 hours per week	2	examine possibility of improved shaft scheduling
obstructions (fall of ground, badly loaded scrap and material)	shaft meshed and laced in lower sections riggers load loose steel at 90l	upper sections need meshing and lacing	7	extend meshing and lacing to upper section of shaft
badly loaded material from surface	none	limited cage space	7	provide loading gauge on surface
poor car condition	surface inspection of cars daily check on hoppers	no procedure to ensure that all cars are checked regularly	7	improve checking system
track switches in shaft	operator training daily inspection	- -	4	- -
Injured while reloading material in incline shaft	gloves training and coaching procedures approved safety boots	gloves not always used, not always effective boots not always effective	7	-

Incline material winder (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Injured while riding on cars	supervision training procedure	-		-
Misuse of material movement procedures due to urgency	-	-		procedure required for authorising movement of urgent material
Injured while moving in travelling way	warning lights provided refuge cubbies provided procedures for travelling in place	-		safety signage required

Kibble winder

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Injured due to rope failure			10	
	Daily and monthly rope examination, recorded in log book	-		-
	magnetic rope test every 6 months	-		-
	rope examination after incident	-		-
	kibble loading procedure to prevent overload	-		-
	training and competence of staff	-		-
Injured due to brake failure			10	
	Daily and weekly examination	-		-
	log book record	-		-
	two braking systems fitted	-		-
	test footbrake every shift	-		-
	test emergency brake daily	-		-
	can apply reverse power to assist	-		-
	training and competence of staff	-		-
Falling from conveyance			12	
	Rules – see entry of Inspector of Machinery in Driver's log book	not always followed		On the job coaching
	supervision	not always present		-
	safety signs	dirty		clean/replace signs

Kibble winder (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Injured due to over or under wind			5	
	Trip switch driven by indicator cam	-		-
	Tarzan wire ultimate limit in headgear,	-		-
	crosshead separation indicator for u/w	-		-
	trip switches tested daily and weekly, recorded in log book	-		-
	overwind trip operation tested on each shift	-		-
	jack catches provided to engage kibble catch plate and kibble rim	-		-
Injured due to attachment failure			10	
	Daily and weekly inspections recorded in log book	-		-
	attachment load test every 6 months, rotate for rest and inspection	-		-
	purchase properly designed and certificated attachments	-		-
Injured by conveyance striking bank doors			2	
	safety trip on dial indicator, tested daily	-		-
	banksman present at all times	-		-
	training of driver and banksman	-		-

Kibble winder (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Injured due to failure of sheaves			10	
	daily and weekly inspection, recorded in log book	-		-
	clean, check and grease sheaves weekly	-		-
	purchase properly designed and certificated equipment	-		-
Injured by falling crosshead			9	
	crosshead separation indicator	-		-
	daily and weekly examination of crosshead, recorded in log book	-		-
	visual examination by banksman as crosshead is rung through bank doors	-		-
	stage ropes examined and greased regularly	-		-
	proper driver's procedures	-		-
	rubber impact buffers provided	-		-

Stage winder

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Injured due to rope failure			10	
	Daily and monthly rope examination, recorded in log book	-		-
	electromagnetic rope test every 6 months	not possible to check full length of rope at one time		-
	rope examination after incident	-		-
	weightometers provided on stage rope attachments	-		-
	training and competence of staff	-		-
Injured due to brake failure			13	
	Daily and weekly examination	-		-
	log book record	-		-
	two braking systems fitted	-		-
	test footbrake every shift	-		-
	test emergency brake daily	-		-
	can apply reverse power to assist	-		-
	training and competence of staff	-		-
	high gear ratio assists braking	-		-
Injured due to fall from stage			12	
	handrails provided	-		-
	safety belts provided	-		-
	rules and supervision	-		-
	daily and weekly examination of stage, recorded in log book	-		-
	stage well lit	-		-

Stage winder (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Injured due to over or under wind			1	
	overwind cam operates trip switch set to just below bank	-		-
	daily and weekly examination of trip switches, recorded in log book	-		-
	manual daily test of switch operation	-		-
	lock bell system	-		-
	dial indicator of stage position	-		-
Injured due to failure of rope attachments in headgear			10	
	Daily and weekly inspections recorded in log book	-		-
	purchase properly designed and certificated attachments	-		-
Injured due to failure of sheaves			10	
	daily and weekly inspection, recorded in log book	-		-
	clean, check and grease sheaves weekly	-		-
	purchase properly designed and certificated equipment	-		-

Stage winder (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by kibble			9	
	screening around kibble hole in stage	-		-
	handrails where necessary	-		-
	lights provided where necessary	-		-
	lockbell provided for stage hand	-		-
	kibble rung down through stage, lights dip to provide warning	-		-

Incline man/material/rock winder
Driver's cabin

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Major incident caused by distraction of driver, due to noise from winder, fan and rock chute	enclosed cabin with door	inadequate insulation various noise sources not controlled	9	investigate improved insulation of driver's cabin investigate sources of noise and apply appropriate controls
Major incident caused by distraction of driver due to: People	signage special instruction SI046	not adhered to due to seating provided, tea and coffee in cabin, related activities	9	investigate provision of rest room facility investigate maintenance scheduling
	code of practice telephone interlocked with brakes	not adhered to, due to: layout of cabin shaft activities	9	apply code of practice consider amendment to code of practice
Major incident caused by driver fatigue	designated break times in Code of Practice toilet facilities available		ALARP	
Slipping and falling while entering/leaving cabin	non-slip steps provided into cabin		7	handrails to be provided

Incline man/material/rock winder (contd)
Winding plant - mechanical & electrical

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Caught in moving machinery	guards provided on immediately accessible parts handrail and signage provided around machinery area (CoP No 12, 9, 3) code of practice to notify driver and lock out winder authorised access only		5	robot light (eg to show green when winder locked out and safe to enter machinery area) investigate provision of pre-start alarm
Struck by burst hydraulic hose	design specifications in place quality hoses purchased from authorised suppliers inspection during daily & weekly checks by fitter low pressure and flow control valves provided access control to machinery area		ALARP	
Slipping/falling due to oil/grease on floor	daily housekeeping spills cleaned up non-slip tiled floor provided		ALARP	
Electric shock while fault finding on live panels	quality test equipment provided, low control voltage training and authorising of staff panels are readily accessible procedures circuit drawings available in workshop	false reading due to battery failure procedure does not specifically address live testing drawings may not always be up to date	12	initiate pre-use check on test equipment consider providing spare batteries draw up procedure for live testing update regularly and check as part of monthly examination

Incline man/material/rock winder (contd)
Shaft operations

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Collapse of dropsets due to failure of hinges and pins	hinges checked daily by fitter	possible underdesign of hinges & pins not formally shown on checklist maintenance activities not completed due to shaft time constraints	13	investigate hinge design install safety underslings fit "banana" hooks under hinge points
Collapse of dropsets due to failure of slings and safety catches	all slings examined daily according to procedure catches and other safety devices examined weekly	maintenance not formally documented	5	replacing single sling with double sling arrangement
Collapse of dropsets due to failure of winch and/or winch rope	weekly maintenance by fitter	maintenance not formally documented	5	formalised winch inspection and maintenance investigate brakes on winch, also underwind, overwind limits and rope coiling
Struck by conveyance while connecting/disconnecting dropset sling	lock bell system between stations and driver	confusion between banksman and driver due to use of "short signals" "open bells" arrangement between banksman and driver (shortcutting)	12	new sling arrangement being installed will eliminate this hazard. (and speed up operations)
Struck by conveyance, either as runaway or when moving on station	single stop block on station banksman/onsetter clears area special instruction regarding positioning of people	stopblock provided to stop cars entering shaft inadvertently, not to protect station area people must be present on station to guide conveyance into/from shaft to prevent rope damage (due to slack rope)	7	investigate re-design of the station (in progress) investigate sloped instead of level dropset investigate designated safe sitting area for station helpers investigate the possibility of stop blocks and other devices to reduce risk due to a runaway conveyance while drop set is down

Incline man/material/rock winder (contd)
Shaft operations (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by loose material from cars	special instruction for onsetter to check all car loading provision of straps etc at all levels		8	material height sensing device being installed on bank and stations
Derailment while offloading cars from conveyance onto station platform			7	improve alignment of rails between crocodile and raised platforms on all levels
Derailment of conveyance when entering/leaving the dropset			4	investigate relative rail elevations and alignments
Slipping and falling whilst moving into/out of conveyance from trap door in the dropset	use of mancage restricted to use by shaft operating personnel ladder inside mancage	ladder not long enough, still a large gap between bottom of ladder and top of mancage	4	investigate alternative means of access - a folding ladder, or landing platform at side provide illumination

Headgear

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Caught in moving machinery	Code of Practice re entry to headgear (CoP12, 10, 18) safety signage provided entry to headgear recorded in driver's log book - special instruction (101 and 102)		4	install lockable gate at entry to headgear
Struck by overwound conveyance	crash beams in headgear overwind protection devices on winder and in headgear trained authorised drivers		ALARP	

Incline man/material/rock winder (contd)
Winder/shaft general

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Rope breakage	daily and monthly inspections magnetic rope tests (every 3 months) cut front and back ends, test front ends slack rope devices bad coiling devices slow braking on winder	slack rope device may not operate when conveyance at bottom of shaft or on station	ALARP	check operation
Over/under wind	mechanical limit switch on each drum Lilly controller on each drum tarzan wire in headgear auto slowdown at end of wind 6 monthly dynamic test, (level 1 audit by 3rd party) limit switch trips tested every shift limit switch trips tested by electrician daily and weekly		ALARP	
Failure of brakes	annual ultrasonic testing of critical brake components by 3rd party daily, weekly and annual inspection each brake performs required total duty		ALARP	
Power failure	Escort controlled brake application, fail safe system		ALARP	

Incline man/material/rock winder (contd)
Winder/shaft general (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Failure of conveyance attachments	shackles and pins NDT every 6 months, rested and inspected movements and inspections recorded split pin changed as necessary, supply of spare pins available daily and weekly inspection by fitter coupling and uncoupling of conveyances only done at bank	supplied by recognised supplier supplied tested and certificated	ALARP	

Incline material winder
Shaft activities

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by runaway conveyance:				
due to brake failure	daily and weekly examination and maintenance by the fitter, recorded in the Machinery Record Book		12	
	driver tests brakes every shift	procedure not followed		review procedure and training of winch operators
due to failure of attachment to hopper and material cars	attachment and pin inspected daily by the fitter, recorded in the Machinery Record Book		14	
	NDT of pin every 6 months			
	all main and overrope slings logged, examined daily and monthly, inspected by engineer every 6 months and replaced every 12 months	possibility of some unnumbered / unrecorded slings in use		Numbering and recording of slings to be done as per Code of Practice 240/0009
		some overropes too long for application		check slings and review procedure with operators
	Rigger inspects all main and overrope slings monthly, and logs result	Slings are often taken from the shaft for other purposes and returned much later after testing date (note that overrope slings are not easily removable from the new material cars)		Review procedure Mine overseer to be responsible for all slings in his area All slings to be made available once per month for checking by the rigger Lockable container to be provided at shaft, enforce use of logbook Update training for bell operators and shaft personnel

Incline material winder (contd)
Shaft activities (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by runaway conveyance (contd)				
due to failure of attachment to hopper and material cars (contd)	all main and overrope slings date stamped	confusion over whether date is in-service date or expiry date		consider colour coding slings to facilitate age identification
		bellman does not check dates		training
	boilermaker checks car attachments once a month and logs result	Material cars not always available on surface (ie left underground or at another shaft)		
		Coupling problems and damage to cars can be caused by non-standardised coupling designs		
due to breakage of winding rope	visual daily inspection by rigger, logged in Machinery Record Book		ALARP	
	monthly cleaning, examination and measurement by Engineer, greasing, logged in Machinery Record Book			
	front end cut for test every 6 months			
	back end cut every 6 months			
	EMT every 6 months			
	rope rollers in shaft to prevent wear			
Derailment due to overloading material	Height/width control gate at bank and stations	No height/width control at 3level or 4 level stations	6	Install control gates at all stations, check gate at bank
	Maximum permissible loads and procedure	Outdated signs at some stations		Check and install correct signs at all stations
Runaway conveyance	Safety drop set provided in shaft below 3L station, operating procedure		14	Check that hitch points are securely fixed

Incline material winder (contd)
Shaft activities (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Overwinds/underwinds	Overwind limit switches (indicator drive and ultimate switch above bank) provided Underwind trip provided on indicator Trips tested daily by electrician and logged in Machinery Record Book Stopbblock provided above bank		ALARP	

Bank activities

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by moving cars	Area under supervision of bell operator	No overall control of people on bank	7	Investigate use of demarcation zone Review training of operator (present training focuses on use of bells, not bank area management)
While loading or unloading cars	Chain sprags provided to stop cars Aeroplane sprags provided Standard procedure regarding offloading	 Aeroplane sprags not used Material car allowed to run free down elevated incline at bank		
Due to unexpected movement of cars	Lock bell system Code of signals Trained operator	Bank and underground bells are on the same system, therefore two operators could give instructions to the driver “Short bells” used Bell operator not always present, possible unauthorised use		Provide separate bell circuits Review training and discipline All bell keys to be locked up by the driver at end of shift, and reissued for the next shift.

Incline material winder (contd)
Station activities (3 level and 4 level)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by moving cars	Area under supervision of bell operator	No overall control of people on station	7	Investigate use of demarcation zone Review training of operator (present training focuses on use of bells, not station area management) Improve illumination
While loading or unloading cars	Chain sprags provided to stop cars Aeroplane sprags provided Standard procedure regarding offloading	Aeroplane sprags not used		
Due to unexpected movement of cars	Lock bell system	Bank and underground bells are on the same system, therefore two operators could give instructions to the driver		Provide separate bell circuits
	Code of signals	“Short bells” used		Review training and discipline
	Trained operator	Bell operator not always present, possible unauthorised use		All bell keys to be locked up by the driver at end of shift, and reissued for the next shift.
Bell operator struck by cars while raising or lowering safety droprail/RSJ	Procedure and code of signals, driver locked out when cars above switch		7	
	Design specification in shaft safety manual	Counterweight in wrong position		Move counterweight out of incline and onto station

Incline material winder (contd)

Station activities (3 level and 4 level) (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Persons on 3 level station struck by runaway conveyance	Safety droprail/RSJ provided above station Drop rails and sets inspected regularly	Safety droprail/RSJ not aligned properly – bottom end of rail to rest on floor when in “down” position	12	Improve suspension and operation of safety droprail/RSJ Consider rail switch which would fail safe to a “straight through” position, possible operation by remote control from station
Persons on 4 level station struck by runaway conveyance	Safety drop set below 3 level station in incline, operating procedure Drop set inspected regularly Safety drop rail/RSJ provided on rail curve into station	Safety droprail/RSJ inadequate; shaft/station design will cause runaway cars to be deflected onto the station	12	Investigate providing a stronger dropset in the shaft above the station, or a “dead end” feature as the shaft bottom, with rail turnout

Incline rock winder

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by runaway conveyance:				
due to brake failure	daily and weekly examination and maintenance by the fitter, recorded in the Machinery Record Book brake wear and brake on/off indication brake rubbing trip brake testing procedure		12	
due to failure of attachment to conveyance	attachment and pin inspected daily by the fitter, recorded in the Machinery Record Book NDT of pin every 6 months		14	
	safety slings logged, examined daily and monthly, inspected by engineer every 6 months and replaced every 12 months	possibility of some unnumbered / unrecorded slings in use		Numbering and recording of slings to be done as per Code of Practice 240/0009
	safety slings date stamped	confusion over whether date is in-service date or expiry date		consider colour coding slings to facilitate age identification
		bellman does not check dates		training
	boilermaker checks car attachments once a month and logs in Machinery Record Book			

Incline rock winder (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by runaway conveyance(contd)				
due to breakage of winding rope	Visual daily inspection by rigger, logged in Machinery Record Book Monthly cleaning, examination and measurement by Engineer, greasing, logged in Machinery Record Book front end cut for test every 6 months back end cut every 6 months magnetic rope test every 6 months rope rollers in shaft to prevent wear slack rope device on winder		ALARP	
Derailment caused by spillage on the track	inspection and cleaning during 2 hour period at start of day shift weekly shaft and box examination by shaft timberman and artisans, logged in Machinery Record Book. visual check on car overloading by box operator water control in boxes and stopes – “Spillminator” mudrush control chutes on reef boxes hangups in waste box due to oversize rock reduced by grizzleys at tipping point Marshall’s device trips winder when conveyance derails	spillage can occur during shift, no access to clean	9	box operator to ensure that operations are safe with visual check during loading

Incline rock winder (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Derailment caused by poor track conditions	weekly shaft examination by shaft timberman and artisans, logged in Machinery Record Book and Shaft Examination Book	not always enough time to maintain and change rails too few trained shaft timbermen available	9	
	monthly shaft examination by Safety Officer, formally logged	unclear communication of safety report topics if shaft timberman not present during safety examination		ensure that shaft timberman is available for Safety Officer inspections
	Marshall device provided			
Runaway conveyance	safety drop sets provided in shaft below loading boxes operating procedure for drop sets	hitch points not properly constructed/maintained	14	check that hitch points are securely fixed
Derailment caused by faulty conveyance	trip wire provided over bins to detect “door open” situation	trip can be reset manually by operators	12	investigate means of securing and interlocking trip feature
Overwind/underwind	overwind limit switches (indicator drive, cam gear and ultimate switch on top of bins) provided auxiliary drive monitor provided on cam gear underwind trip provided on indicator and cam gear trips tested daily by electrician and logged in Machinery Record Book stopblock provided on top of bins		ALARP	

Vertical man/rock/material winder
Hoist room

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Slip and fall	level non-slip floor		7	
	cable trenches covered			
	demarcated walkway	not complete		complete demarcation
	housekeeping	not fully effective		more discipline and supervision
	weatherproof roof	some water leaks		repair as necessary
	steps to cabin			
	illumination	not easy to see outside cabin area		undertake lighting survey and implement
Electrocution			9	
due to tampering	all panels enclosed			
	all live conductors enclosed in panels			
	warning notices			
	open panel trips fitted	not fitted to all panels		assess situation and fit accordingly
	accepted practice	no formal procedure		formalise instruction
while fault finding	trained and competent staff, authorised and appointed	not always up to standard, especially new recruits		review manpower needs and standard of in-house training
	no exposed power conductors			
during cable theft	locked hoist room	hoist room forms part of perimeter		re-organise perimeter fencing
	area illumination and security	not fully effective		check illumination and alarms
Caught in moving machinery	guards/handrails	not always replaced	3	improve discipline/attitude
	signs	missing		replace
	illumination	limited		conduct lighting survey
	control access to hoist room	missing		improve access control

Vertical man/rock/material winder (contd)
Hoist room (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by broken winding rope	overwind protection overcurrent protection engineer present during dynamic test regular maintenance, inspection and testing		-	

Headgear

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Caught in moving machinery (ropes, sheaves, skip)	barrier provided handrails and guarding signage no person allowed in sheave area when winder operating procedure for tipman to give clear to driver	can be bypassed or opened could be confusing no written procedure, driver may not hear signal		procedure and lock/key control improve signage investigate situation
Slipping and falling	proper walkways and stairs with landings handrails on both sides illumination housekeeping PPE discipline	poor not always effective (time constraint) production pressures	4	assess illumination improve and review maintenance schedule

Vertical man/rock/material winder (contd)
Headgear (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Falling from height during normal operation during repairs	 handrails illumination proper walkways safety harnesses provided	 belt and chain type single lanyard (hazard when moving)	9	 use full body harness procedure and hazard training
Struck by lightning	headgear earthed	not checked	-	
Falling objects	housekeeping proper floor grating PPE visual checking of skip loading at box	not always done control of skip load not always effective when rock jams in radial door	4	improve and review maintenance schedule provide brattice between compartments
Collapse of headgear	checked by professional engineer regular maintenance weekly examination logged in Record Book.		-	

Vertical man/rock/material winder (contd)
Bank

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Slipping and falling on bank area	housekeeping PPE illumination bank management	not always effective just outside bank patchy step up from road tank trap	7	improve discipline and supervision undertake lighting survey investigate and improve bank management
when climbing in / out of skip	ladder into skip	very awkward access		investigate and improve
Falling down shaft while loading material	only a small gap between bank and skip adjacent shaft bratticed off		6	
while doing skip examinations	safety belts training accepted practice	not always worn belt and chain type single lanyard (hazard when moving) no formal procedure, not always used		design and install platform use full body harness procedure and hazard training provide procedure, improve discipline and supervision
while loading men	only a small gap between bank and skip adjacent shaft bratticed off	overloading - no room for travelling onsetter		improve supervision and control consider banksman and onsetter during peak periods
while slinging material	procedures	not always practical or used		review procedure and work method
from bank area	shaft gates	gates on winder side often left open due to poor housekeeping		improve supervision and discipline

Vertical man/rock/material winder (contd)
Bank (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Falling objects				
general	housekeeping in headgear proper floor grating PPE	not always done	4	improve and review maintenance schedule
spillage from tip	visual checking of skip loading at box	control of skip load not always effective when rock jams in radial door		provide brattice between compartments
Struck by vehicle	visual awareness	not sufficiently effective	8	provide reflective clothing
	driver control/licensing			identify and demarcate roads
	no vehicles during shift times	only coincidental		formalise
	vehicle noise			check vehicle safety features (reversing alarms etc)

Vertical man/rock/material winder (contd)
Station

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Slipping and falling			7	
on station	housekeeping	not always effective		improve discipline and supervision
	PPE			
	illumination	patchy		undertake lighting survey
when climbing in / out of skip	ladder into skip	very awkward access		investigate and improve
Falling down shaft			6	
while loading material	only a small gap between station and skip			
	adjacent shaft bratticed off			
while loading men	only a small gap between bank and skip	overloading - no room for travelling onsetter		improve supervision and control
	adjacent shaft bratticed off			consider banksman and onsetter during peak periods
while slinging material	procedures	not always practical or used		review procedure and work method
from station area	shaft gates			
Falling objects				
general	PPE		4	
	bratticing			
	weekly shaft examination, logged in Record Book			
spillage from tip	visual checking of skip loading at box	control of skip load not always effective when rock jams in radial door		provide brattice between compartments

Vertical man/rock/material winder (contd)
Shaft

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by falling objects	canopy over skip no work allowed in headgear while hoisting PPE	skip not totally enclosed	2	consider use of cages for men
Injured in runaway skip due to brake failure due to rope failure due to attachment failure	overspeed alarm and trip on each drum failsafe brakes daily inspection of main brakes weekly inspection and test, logged in Record Book 6 monthly dynamic test by specialists annual NDT of critical components daily inspection monthly measurement and inspection by Engineer, logged in Record Book 6 monthly magnetic rope test 6 monthly front end cut and load test daily check by fitter, logged in Record Book monthly inspection by Engineer 6 monthly rotation and NDT 2 spare sets available		10	

Vertical man/rock/material winder (contd)
Shaft (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Shaft movement				
progressive	visual weekly shaft examination results recorded and monitored		10	
catastrophic	driver vigilance slack rope device on winder	does not control cause effectiveness in reducing severity is questionable	very low	
Injured while using ladderway from station to bank	only travel from highest station ladderway bratticed off from skip weekly shaft examination ladderway examined every 10 days maintenance and repair procedure for washing bank at certain times	 repairs not done immediately sometimes men use ladder while washing in progress	7	 keep spare ladder available
Injured by rocks from skip due to door opening unexpectedly	tip man checks latches skipman checks latches before loading skip cleaned as necessary accepted practices penthouse protection for skipman at box	might not see might not see informal	4	improve illumination improve illumination special instructions and procedures

Vertical man/rock/material winder (contd)
Loading box

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by moving skip	only authorised persons in area men do not work near skip	personnel could look into shaft	2	investigate layout of bratticing
Struck by rocks from waste chute	radial gate and chute	not fully effective	7	install protection plate between chute an dwalkway investigate modifications to waste pass
Falling from height	gates, handrails and flooring	may not be fully effective	2	check possible gaps in floor and height of gates
Slipping and falling	housekeeping illumination non-slip garting PPE access to waste boxes	 not adequate wooden steps uneven and slippery	4	 undertake lighting survey provide proper steps and platform
Noise from compressed air exhaust of air cylinders	noise survey carried out, low exposure PPE available		-	pipe exhaust air away from area
Mudrush from reef boxes	mix mud with drier reef, keep water out of passes (Special Instruction) do not use water to unblock passes (Special Instruction) radial gate control valve returns to “closed” position PPE upper inspection flaps pinned closed	 valve position is in front of boxes not used	7	 improve discipline

Vertical man/rock/material winder (contd)
Loading Box (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Hand injuries from use of pinch bar	hand protector on pinch bar PPE – gloves Special Instructions various lengths of pinch bar provided	not always in place not always available	7	improve discipline provide proper tools
Failure of box structure	weekly inspection by shaft timberman, logged in Record Book mid week inspection by boilermaker maintenance and repair as needed		2	

Incline material winder
Shaft Bottom

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Slipping and falling	safety belts inertia reel 'Sala" blocks chain ladder, inspected every week and result logged	no procedural instruction for working in shaft bottom	7	prepare procedure
Fall of ground	visual check inspect/bar down at start of shift (covered by legal requirement and Special Instruction) weekly shaft exam, logged in Record Book PPE to mine standard		12	
Handling material			7	
rails and sills	visual checks 2 rope blocks used to lower rails & sills men stay above material being moved PPE to mine standard	no procedural instruction for lowering rails & sills		prepare written procedure
materials and tools	visual checks on elephant's foot bags and ropes used for lowering	inspections are informal		prepare written procedure
Falling objects	station platform on 3 level procedure to control men shovelling rock and moving material on platform when there are men underneath supervision	gaps in station platform not all necessary openings have kickflats	7	check station platform

Incline material winder (contd)
Shaft Bottom (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by moving conveyance	procedures and instructions for men to vacate shaft bottom when skip is moved		2	
	skip does not move below station level	no underwind limit on winder		fitting of underwind in progress
	supervisor operates bell and enforces instruction	bellman cannot lock winder		investigate a winder lockout system operable from the station platform
	training and daily 5 minute Green Area discussion			
Struck by runaway conveyance	procedure for personnel to leave shaft before conveyance is moved		6	
due to brake/mechanical failure	main brake tested every shift	procedure not clear, ammeter missing and not visible to driver		put in place procedure for driver to check main brake against ammeter reading
	main and emergency brake provided			
	weekly inspection by fitter and electrician (logged in Record Book), also test of emergency brake			
	annual inspection and NDT all linkages			
	winder design and control limits speed			
	bank doors provided			
due to rope failure	weekly visual inspection by fitter	visual inspections only		
	monthly inspection and measurement by rigger and engineer, logged in Record Book			
	monthly greasing			
	front end cut and load test every 6 months			
	shaft rollers provided to reduce wear on rope	rollers removed for rail slinging		re-install as soon as possible

Incline material winder (contd)
Shaft Bottom (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by runaway conveyance (contd)				
due to attachment failure	weekly inspection of attachments by fitter	design of one shackle does not allow for split pin		check design of shackles
	annual inspection and NDT	no load test		consider load test when new and then annually
	spare attachments available			
		design of forged pivot bar attaching bridle to skip does not allow for proper inspection		review design

Incline material winder (contd)
3 level station

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Fall of ground	visual check inspect/bar down at start of shift (covered by legal requirement and Special Instruction) weekly shaft exam, logged in Record Book PPE to mine standard		12	
Collapse of platform	daily visual check weekly shaft exam logged in Record Book main beams pinned and grouted		6	
Slipping and falling			7	
on platform	firm landing	damp and slippery at times		
	handrails	not at skip opening		provide handrail/gate
	housekeeping			
	illumination			
while unloading skip	plank access to skip	no method of attaching safety harness		provide lifeline
	safety harness			
	supervision			
Handling material on platform and from skip	supervision illumination job planning proper tools special instructions team work		7	

Incline material winder (contd)
3 level station (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Falling objects	weekly shaft exam logged in Record Book daily visual checks penthouses kept clean (Special Instruction) bank doors shaft cleared for maintenance or repair	might not be clean at all times	7	monitor occurrence

Shaft

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Injuries due to derailment	weekly conveyance examination by fitter, logged in Record Book weekly shaft examination, logged in Record Book no persons allowed in shaft while conveyance is in motion slow speed winder	no interlock or lockout on winder	9	Marshall wires will be installed to trip winder in the event of a derailment of conveyance
Falling objects	weekly shaft exam logged in Record Book daily visual checks penthouses kept clean (Special Instruction) bank doors shaft cleared for maintenance or repair	might not be clean at all times	7	monitor occurrence

Incline material winder (contd)
Shaft (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Slipping and falling	shaft ladders provided with back hoops weekly shaft examination, logged in Record Book penthouses every 6m cleaning of penthouses (Special Instruction) mine standard PPE	some hoops damaged, rungs too close to footwall limited action on repairs etc following shaft exam	7	improve housekeeping/maintenance improve follow up (procedure required to "close the loop"
Struck by moving conveyance	procedures and instructions for men to vacate shaft when skip is moved supervisor operates bell and enforces instruction training and daily 5 minute Green Area discussion	bellman cannot lock winder	2	fitting of underwind in progress investigate a winder lockout system operable from the station platform
Struck by runaway conveyance	procedure for personnel to leave shaft before conveyance is moved *also other controls listed under "Shaft Bottom"*		6	
Fall of ground	visual check inspect/bar down at start of shift (covered by legal requirement and Special Instruction) weekly shaft exam, logged in Record Book PPE to mine standard		12	

Incline material winder (contd)
Bank area

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Slipping and falling	housekeeping bank doors illumination step down to shaft ladder	housekeeping of limited effect doors often left open some areas in shadow at night poor access to ladder	7	improve monitoring and supervision, barricade area with handrails, gates, etc to prevent unauthorised access provide signs and procedures improve access arrangement
Struck by moving conveyance	conveyance visible to people at risk audible when moving bell signals nearby driver's visual check	open area, access not controlled might not hear bells	2	prevent unauthorised access

Headgear

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Slipping and falling	handrails backhoops on catladder treaded steps illumination	no handrail on shaft side of steps	7	check and install
Falling from height	proper stairway provided safety belts used when need to work outside handrails (Special Instruction)	bottom of stairway adjacent to shaft entrance	5	redesign/reroute bottom of stairway
Caught in moving machinery	access to upper area restricted to competent persons lighting winder locked out when working near sheaves	poorly implemented	5	provide locked gate at bottom of catladder to sheaves provide procedure
Lightning	headgear earthed, no personnel on headgear during a storm	theft of cable	3	regular checks in rainy season annual conductivity check

Incline material winder (contd)
Winder House

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Caught in moving machinery	guards provided warning signs provided to restrict access illumination space around machinery	rope area exposed check lockout procedures	5	provide barricade / handrails
Slipping and falling	housekeeping level floors illumination	cable trench open	4	provide cover over trench
Struck by broken rope caused by overwind	low power of winder	no overwind protection	-	indicator overwind and tarzan wire will be installed install 3 turn warning on bank approach
Electrocution during maintenance	lockout procedure only trained, competent and authorised staff work on winder locked panel, opened with special key	on occasion need to check operation of control circuits	8	consider providing a cut out switch on panel door procedure recommended for testing inside live panel
Fire	fire extinguisher provided training extinguishers checked by registered external company and engineer every 6 months monthly check by shaft foreman visual and smell detection by driver		1	

Incline material winder   Hoist room

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Heat and air quality	fan column and venturi	temperature not low enough, may exceed minimum standard of 31.5 deg when winder is in use	3	consider installation of spot cooler
	ventilation checked regularly	not considered a priority issue		ensure compliance with procedure
	driver has right to withdraw	production pressure		improve driver awareness
	dead man control on hoist			
Caught in moving machinery	guards	no guard on indicator chain drive	6	fit guard
	hoist room screened off and locked	general machinery area not protected		demarcate / protect machinery area
	pre-use checklist			
	deadman switch on hoist			
	notices			
	adequate working space			
	illumination			
	driver remote from moving parts			
Bad hanging	wire mesh and lace	corrosion of mesh	5	
	permanent support to mine standard			
	weekly inspection logged in book			
Slipping and falling	good housekeeping		2	
	inspections and maintenance			
	illumination			
	floor demarcation	does not comply with new mine standard		check colour coding and apply

Incline material winder (contd)
Hoist room (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Electrocution due to panels left open	control panel locked	can be easily opened material stored inside panel	9	keep panel properly locked provide storage box
while working on live control panel	training and competence of staff procedures	no manual supplied by manufacturer		
Struck by broken winding rope	relevant controls as per “Shaft” section screening at front of hoist room		-	

Shaft

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Runaway conveyance (general)	safety drop rails in shaft proper travelling way provided, direct access to and from stations no unauthorised persons permitted in winding compartment	not operative, not properly attached to hanging	6	check inspection and followup attach as per mine standard
Runaway conveyance caused by broken winding rope due to poor rope maintenance and inspection	rigger inspects weekly and logs in book fitter does visual weekly check and logs in book	rigger not available fitter may not have required skills rope record book not used front ends not cut or logged in book magnetic rope testing not done no load test	6	review staff levels check multi skill modules, train being implemented check when previous tests were done and adhere to Procedure EI 4.13.1 (a) consider including this test

Incline material winder (contd)
Shaft (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Runaway conveyance caused by broken winding rope (contd)				
due to overwind / overspeed	overwind switch inspected and tested weekly overspeed switch provided	disconnected while slinging certain loads not operative		check / provide procedure for this situation consider replacing or removing
due to excessive load in conveyance	maximum load specified and displayed rigger required for heavy loads	procedures not always adhered to rigger not always available and has minimal assistance. Fitter usually does job		review staff levels check multi skill modules, train
due to slack rope incident	weekly shaft examination and maintenance, logged in book boilermaker inspects pilot car weekly and logs in book	no examination of material cars		consider implementing suitable procedure
due to drop sets being in shaft	drop set indication in hoist room drop set cannot be operated without lock bell key training and supervision	not operative can be operated while hoist in motion		review weekly inspection procedure consider interlocking with hoist
due to absence of rope rollers in shaft	regular inspections and maintenance	lowbed cars damage rollers		check design and installation of rollers check clearances before using lowbed

Incline material winder (contd)
Shaft (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Runaway conveyance due to failure of attachment between rope and pilot car	weekly inspection by fitter, logged in book purchased from reputable supplier	no record or management system	6	provide and implement procedure
attachment between pilot car and material car	fitter inspects load sling weekly, logs in book purchased from reputable supplier	no record or management system no inspection of coupling pins no control, any pin could be used		provide and implement procedure for management of attachments
safety slings on material car	slings inspected by fitter weekly and logged in book purchased from reputable supplier colour coded and tagged with date length of service check	no spares on site slings too long for application not always same size as winding rope (required by Procedure) conflicting procedures		review needs and provide slings training, supervision, toolbox talks review procedures
Runaway conveyance due to hoist brake failure	emergency brake provided weekly inspection by fitter, logged in book main brake tested by driver each shift	not tested brake pins cannot be easily removed for annual inspection not tested against ammeter	6	develop and implement procedure amend procedure
Bad hanging	wire mesh and lace permanent support to mine standard weekly inspection logged in book	corrosion of mesh	8	

Incline material winder (contd)
Shaft (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Slipping and falling	proper travelling way provided proper handrails provided illumination regular examination and repair	breaker in steps creates hazard hookup on meshing corroded stair treads, responsibility not clearly defined	7	assess and check legal requirement check / repair define and implement procedure, repair
Derailment caused by falls of ground	meshing and lacing permanent support weekly inspection, logged in book	corrosion of lacing	6	regular checks and repair
poor track conditions	weekly inspection and maintenance proper design and installation to mine standards			
High pressure water and air from pipelines	proper installation of pipelines ongoing maintenance and checks	gaskets not designed for life pipelines not designed to accommodate small ground movements	-	provide warning notices
Electrocution resulting from cable damage	proper cable supports regular inspection meshing and lacing electrical protection	racking corroded, located near pipes	-	consider rerouting in winding compartment

Incline material winder (contd)
Stations

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Struck by and caught by / under moving cars			11	
while coupling / uncoupling	correct coupling equipment (wheel sprags, hooks, slings)	not always available, not always in good condition, not always used properly		supervision, toolbox talks, motivation, provide equipment
	competent and authorised personnel	only one person on station		
	standard procedures	not always followed		review work procedures
	PPE			
while bringing cars onto station from haulage	procedures	poor communication between shaft crew and haulage crews / loco driver, noise in area		review procedure on each station in detail
	competent and authorised personnel			
	procedures for abnormal loads			
	visual control by loco driver	line of sight often obstructed		
	station safety devices and station management	devices create tripping hazard		
due to unexpected movement of cars caused by distraction or reduced alertness of hoist driver	access control at hoist room	telephone in hoist room		
	signage at hoist room			
	ventilation in hoist room	refer to “Hoist room” section		refer to “Hoist room” section
due to unexpected movement of cars caused by use of more than one lock bell key in shaft	lock bell signalling system	more than one key in use		
		no formal procedure		
		no interlock to prevent inadvertent use of bell when conveyance not at level		

Incline material winder (contd)
Station (contd)

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Falling from height from station into shaft	procedures shaft gates drop set	cannot always be followed because car sometimes stops on drop set while being lowered	9	investigate angle of drop set
from station drop set into shaft while re-railing cars	code of practice for operation and installation of station dropset	possible derailment of cars due to car overhang not being suited to angle of station dropset		check and correct as necessary review procedure for re-railing cars
Slipping and falling	control of station by bell operator illumination good housekeeping conveyor belt laid between rails to facilitate cleaning up of rope grease	walkway not demarcated station safety devices unguarded moving rope	7	provide a marked walkway maintain good housekeeping
Bad hanging	wire mesh and lace permanent support to mine standard weekly inspection logged in book	corrosion of mesh	5	

Incline material winder (contd)
Incline / winder system operating over a brow

Potential Hazard	Current controls	Shortcomings	R	Recommendations
Runaway conveyance due to broken rope caused by			12	
excessive slack rope over brow	procedure for moving cars over brow training and supervision hoist driver and operators in visual contact	shortage of manpower to comply with procedures, sometimes the driver has to move the cars himself, sometimes a bellman from a lower level has to leave his station to assist supervision often not available		review procedures and manning requirements for each specific application
physical damage to rope (ridden over by cars on bank, cyclical loading, bad coiling and kinks)	procedure for moving cars on stations training and supervision	shortage of manpower to comply with procedures, sometimes the driver has to move the cars himself, sometimes a bellman from a lower level has to leave his station to assist supervision often not available		review procedures and manning requirements for each specific application
Struck by moving car while pushing over brow by hand or by loco	procedure for moving cars over brow	shortage of manpower to comply with procedures	11	review procedures and manning requirements for each specific application
	training and supervision	supervision often not available		review procedures and manning requirements for each specific application
	hoist driver and operators in visual contact	often loco is pushing cars around a curve		
	station safety devices	opened for movement of cars		
The whole operation of the "over the brow" installation requires much greater management and control than other designs. Any shortcomings will be reflected much more readily in serious accidents.				

Appendix 7
Checklist of potential control limitations

Checklist of potential control limitations

Winder Machinery

Control	Potential Limitations
Overwind/underwind protection	may need to be disconnected when long loads are raised – special precautions not taken disconnected units not reconnected units damaged and not repaired
Thruster brakes	limited effectiveness in emergency situations
Three turn warning alarm	difficult to hear over background noise
Lock bell system	bank bell and shaft bells on one electrical circuit system not interlocked with brakes unauthorised use of lock bell key multiple lock bell keys used in single shaft adoption of informal/abbreviated signalling systems eg. “Open bells” to avoid repeated locking of winder brakes “Short bells” to expedite shaft operations onsetters and banksmen not trained in correct signalling code
Slack rope detection	ineffective on incline shafts due to low rope tensions, especially when conveyances are moved onto the stations
Brake inspections and tests	not carried out on a routine basis results not formally logged in appropriate record book ammeters giving reading of motor current for brake test purposes not visible to driver failure to define and communicate critical values of motor current to driver and engineering staff staff not familiar with correct brake testing procedures electrical interlocks need to be bridged to test emergency brakes

Checklist of potential control limitations (contd)

Ropes

Control	Potential Limitations
Shaft rollers	not located or aligned for optimum effectiveness rollers jammed/stuck damaged by use of incorrect material cars damaged rollers not identified and repaired removed and not replaced
Rope inspection and testing	shortage of competent/qualified staff regular front end cut and testing not undertaken rope inspection records not maintained
Control of brake application	slow braking mode characteristics not defined and set different braking rates not applied when raising and lowering conveyances
Load control	maximum loads and number of materials cars that can be transported at one time not defined and communicated lack of competent/qualified staff to supervise movement of heavy/awkward loads

Physical barriers etc.

Control	Potential Limitations
Safety drop rails and safety drop sets	do not make contact with footwall when lowered not located or aligned for optimum effectiveness attachment anchor points not sufficiently robust damaged and not maintained incorrectly used – sometimes defeated onsetter needs to adopt unsafe position to operate
Tank traps	can be defeated – transfer cars left in “straight through” position
Bank doors	can be left open
Barriers	not located for optimum effectiveness not sufficiently robust
Stop blocks, chain sprags, aeroplane sprags etc.	not always provided not always used

Checklist of potential control limitations (contd)

Conveyances and attachments

Control	Potential Limitations
Conveyances	
Design & selection	failure to use specified purpose-designed units on inclines – standard mine cars sometimes used instead inadequate clearance over rope rollers in shaft insufficient strength e.g. not always fitted with solid drawbars incompatible coupling arrangements between cars
Inspection/maintenance	Wear and tear not identified Damage not repaired timeously
Attachments	
Correct design/selection	design criteria not always specified non-standard attachments sometimes used lack of spare/replacement equipment of correct standard
Inspection/maintenance	poorly defined allocation of responsibilities for inspections damaged attachments not replaced correct inspection procedures not carried out
Safety slings	too long for given application can be removed for other uses correct inspection procedures not carried out damaged slings not replaced not fitted with identification tags confusion over dates stamped on identification tags

Shaft and shaft equipment maintenance

Control	Potential Limitations
Shaft Inspections	constrained by production pressures; not formally logged and/or recorded; visual/illumination restrictions

Checklist of potential control limitations (contd)

Safe positioning

Control	Potential Limitations
Prevent people taking up unsafe positions	
Guards and covers	sometimes left off
Handrails/barriers etc	damaged/not maintained not located in the correct position gaps and discontinuities not sufficiently robust mountings insecure handrails too low
Lock-bell systems	not always interlocked with winder
Demarcated safety areas/refuges	design/arrangement provides only limited protection inappropriate provision and location sometimes ignored need to work outside
Bank doors	can be left open especially on steep incline shafts
Warning people of risky situations	
Visual warning/warning signs	line of sight restrictions not attention gaining not legible damaged/not maintained
Audible warnings	warning can not be heard damaged/not maintained

Falling from heights

Control	Potential Limitations
Access stairs, ladders, and walkways,	rungs too close to footwall damage to handrails, rungs, platforms, backhoops etc excessive step heights wet/Slippery surfaces inadequate lighting and restricted vision uneven ground/floor conditions insufficient handholds on temporary platforms
Bank doors	can be left open especially on steep incline shafts can be too heavy and difficult to operate manually

Checklist of potential control limitations (contd)

Falling from heights (contd)

Control	Potential Limitations
Handrails, fencing barriers etc.	damaged/not maintained gaps and discontinuities not sufficiently robust mountings insecure
Covers over trenches/gullies	not provided not in place
Personal protective equipment	appropriate type not provided not always used/used incorrectly

User reliability

Control	Potential Limitations
Driver's desk design	poor standard of control and instrument design restricted lines of sight/fields of vision glare from sunlight and poorly located lights extremes of temperature distractions from presence of unauthorised personnel
Driver and onsetter training	formal training based on use of different type of winder/system of operation no provision of regular refresher training induction and refresher training fails to address small winder issues
Pre-use inspections	sometimes ignored inappropriate documentation used failure to over-inspect failure to follow up with remedial action

Falling objects

Control	Potential Limitations
Kickboards	damaged/Not in place Fail to prevent ingress of small items
Screens	gaps in screens too small and/or not strong enough damaged

Checklist of potential control limitations (contd)

Falling objects (contd)

Control	Potential Limitations
Canopies over conveyances	not always set in place difficult to remove/replace
Bank doors	can be left open, especially on steep incline shafts
Load security straps/binding	appropriate type not provided tools/appliances not available not correctly applied
Demarcated safety areas	design/arrangement provides only limited protection sometimes ignored need to reach controls or work outside
Housekeeping	not reliably undertaken