

Health and Safety Risk Management Manual



for the
Australian
Coal Mining Industry

2007

Preface

Background

The effective management of risk is a key issue for all Australian mines. The recent trend towards performance based occupational health and safety legislation and standards has required mines to develop risk management programs and processes that identify, assess and control workplace hazards.

Poor risk management processes cause fatalities, serious injuries and illness and yet in the Australian (and indeed the world) context, while there is much information available regarding generic risk management techniques and practices, there is a significant gap in guidance material that is available for the management of risk and risk communications within Australian coal mines. It is also of note that what material is available is difficult to access, is fragmented and scattered.

Project to improve Risk Management in Australian Mines

This manual and data base has been funded by the Coal Services Health and Safety Trust. The project is designed to assist in developing a more cohesive and sophisticated understanding of risk management and risk communications within the coal mining industry.

This manual and data base provides generic guidance for establishing and implementing effective occupational health and safety risk management processes in mines. It demonstrates how to establish the proper context of a mining operation, and then how to effectively identify, analyse, evaluate, treat, communicate and monitor risks. The manual includes:

- A detailed overview of risk management processes in relation to coal mining;
- A best practice methodology detailing aspects of hazard identification, risk assessment and control in coal mines;
- Development of comprehensive hazard listings for underground and open cut mining processes;
- Practical checklists for conducting and recording the results of risk assessments;
- A data base for the risk ranking of specific mining hazards; and
- Worked examples of specific hazards using identified methodologies

This manual provides a reference for safety professionals, mine managers, health and safety representatives, operators, technical staff, line managers and staff when developing processes, systems and techniques for managing risks.

The contents are intended to provide a broad overview of contemporary risk management as it applies to coal mines. Organisations are expected to interpret this manual in the context of their own operations and develop specific approaches to manage their risks.

Contents

Preface	i
Contents	ii
Table of Figures	iv
Appendices	iv
1. Introduction	1
1.1 Contents and Structure of this Manual	1
1.2 Purpose	1
1.3 Objective	2
1.4 Relationship to Australian Standards and other resources	2
1.5 Definitions	2
2. Risk Management Process	5
2.1 Overview	5
2.2 The Risk Management Framework	5
3. Establish the context	7
3.1 Overview	7
3.1.1 Establish the external context	7
3.1.2 Establish the internal context	8
3.1.3 Establish the overall risk management context	8
3.1.4 Define the structure for the rest of the process	9
4. Hazard Identification	10
4.1 Overview	10
4.2 When should Hazard Identification (HAZID) be conducted?	11
4.3 Hazard Identification Process	12
4.4 Hazard Identification Tools	13
4.5 Detailed Hazard Identification Tools	14
4.6 Hazard Identification Team	15
4.7 Hazard Identification Report	17
4.8 Critical Success Factors	17
5. Introduction to Risk Assessment	18
5.1 Preparation	18
5.2 Adopting a Systematic Approach	19
5.3 Selecting a risk assessment method	20
5.4 Risk Assessment Team	20
5.5 Recording the Process	22
5.6 Communicate and consult	23
6. Risk Assessment - Process	24
6.1 Overview	24
6.2 Types of Analyses	25
6.2.1 Qualitative	25
6.2.2 Semi Quantitative	25
6.2.3 Quantitative	26
6.3 Evaluate Risks	27

6.4	Treat Risks.....	27
6.4.1	General.....	27
6.4.2	Identifying options for the treatment of risks	27
6.4.3	Assessing risk treatment options.....	29
6.4.4	Evaluating risk treatments.....	30
6.4.5	Preparing and Implementing Risk Treatment Plans.....	30
6.4.6	Communicate and Implement	31
6.5	Monitor and Review	31
6.6	Managing Change.....	32
7.	Risk Assessment Tools	33
7.1	Examples of Qualitative Assessment.....	33
8.	Examples of Detailed Risk Assessment Tools.....	36
8.1	Fault Tree Analysis	36
8.2	Event Trees.....	37
8.3	Bow Tie Diagram	38
8.4	Critical Success Factors	39
9.	Assessing the Effectiveness of Controls	40
9.1	Critical Success Factors	40
9.1.1	The Risk Control Practices Matrix	40
10.	Risk Management Data Base.....	42
11.	On-going Management of Risk	55
11.1	Risk Register.....	55
11.2	Management Systems.....	55
11.3	Continual Improvement.....	59
11.4	Auditing the process	59
12.	Resources	61
13.	References	62

Table of Figures

Figure 1: Risk Assessment Process	6
Figure 2: External Risk Management Context	7
Figure 3: Internal Risk Management Context	8
Figure 4: Risk Management Process in Detail	9
Figure 5: Overview of Mine Wide Hazard Identification Process	10
Figure 6: Conveyor Guarding and Access Hazards	11
Figure 7: Plant and Equipment Maintenance Hazards	12
Figure 8: Hazard Identification Team in the Workshop	15
Figure 9: Potential Electrical Hazard	21
Figure 10: Unlabelled fluid bottles	27
Figure 11: Hierarchy of Control	28
Figure 12: Control Options Matrix	29
Figure 13: Risk Matrix	34
Figure 14: Risk Nomogram	34
Figure 15: SPEAR Matrix	35
Figure 16: Simplified Fault Tree	36
Figure 17: Worked Example of Fault Tree	36
Figure 18: Event Tree	37
Figure 19: Bow Tie Diagram	38
Figure 20: Health and Safety Management System Elements	56

Appendices

Appendix 1: Key Coal Mining Risks Listing	i
Appendix 2: Risk Description Examples	v
Appendix 3: Example of Cumulative Mining Hazards Listing	vi
Appendix 4: Example of Mining Hazards Key Words	vii
Appendix 5: Example Risk Management Plan	viii
Appendix 6: Team Based Risk Assessments	ix
Appendix 7: Example of a Risk Register	x
Appendix 8: Life Cycle Map – Underground Coal Mine	xi
Appendix 9: Life Cycle Map – Open Cut Coal Mine	xii
Appendix 10: Government Resources	xiii
Appendix 11: Australian Industry Associations	xiv
Appendix 12: International Government OHS Agencies	xv

1. Introduction

1.1 *Contents and Structure of this Manual*

This manual sets out the hazard identification and risk assessment processes relevant to Australian coal mines. It outlines some of the approaches that can be used to manage occupational health and safety risks. The manual contains:

- A detailed overview of risk management;
- A best practice methodology detailing aspects of hazard identification, risk assessment and control;
- Hazard listings for under
- ground and open cut mining processes;
- Practical checklists for conducting and recording the results of risk assessments;
- Worked examples of specific hazards using identified methodologies; and
- A data base for the recording, risk ranking and development of controls for mining hazards.

This manual follows the risk assessment process from providing an overview, setting the context through to assessment and control. It is divided into ten sections consisting of:

1. Introduction
2. Risk Management Process
3. Framework for Risk Management
4. Hazard Identification
5. Risk Assessment
6. Risk Assessment Tools
7. On-going Management of Risk
8. Resources
9. References
10. Risk Management Tools and Checklists

1.2 *Purpose*

The purpose of this manual is to provide practical assistance to mine managers, employees and other stakeholders to improve the management of occupational health and safety risks within the Australian coal mining. The manual brings together a series of risk management guidelines, strategies and tools specifically designed for improving risk management processes.

The manual uses practical and proven approaches to hazard identification and risk assessment techniques. The manual is designed to act as a catalyst to improve the quality of hazard identification and risk assessment processes within the Australian coal mining industry.

1.3 Objective

The objective of this manual is to provide guidance that will enable all stakeholders within the coal mining industry to:

- Better identify and assess occupational health and safety hazards;
- Improve occupational health and safety risk management processes, controls and management systems;
- Effectively undertake or participate in hazard identification and risk assessment studies; and
- Improve the standard of risk management processes within the Australian coal mining industry.

1.4 Relationship to Australian Standards and other resources

This manual is not intended to replace existing Australian Standards nor other guidance material but is designed to support the mining industry to manage occupational health and safety risks. The content of this manual is consistent with the intent of *AS 4360: Risk Management* and is based on the principles contained within that standard.

1.5 Definitions

For the purpose of this manual, the definitions below apply.

Consequence

The outcome or impact of an event. There can be more than one consequence from one event and the consequences can range from positive to negative. Consequences can be expressed qualitatively or quantitatively.

Control

An existing process, policy, device, practice or other action that acts to minimize negative risk or enhance positive opportunities. The word 'control' may also be applied to a process designed to provide reasonable assurance regarding the achievement of objectives.

Control assessment

Systematic review of processes to ensure that controls are still effective and appropriate. Periodic line management review of controls is often called 'control self assessment'.

Event

Occurrence of a particular set of circumstances. The event can be certain or uncertain and can be a single occurrence or a series of occurrences.

Frequency

A measure of the number of occurrences per unit of time.

Hazard

A source or situation with a potential for harm in terms of human injury or ill health, damage to property, damage to the environment, or a combination of these.

Incident

Any unplanned event resulting in, or affected by, the OHS performance of an organisation.

Likelihood

Used as a general description of probability or frequency and can be expressed qualitatively or quantitatively.

Loss

Any negative consequence or adverse effect, financial or otherwise.

Monitor

To check, supervise, observe critically or measure the progress of an activity, action or system on a regular basis in order to identify change from the performance level required or expected

Organisation

Group of people and facilities with an arrangement of responsibilities, authorities and relationships. This can include a company, corporation, firm, enterprise, institution, charity, sole trader, association, or parts or combination thereof.

Probability

A measure of the chance of occurrence usually expressed as a number between 0 and 1.

Residual risk

Risk remaining after implementation of treatment.

Risk

The chance of something happening that will have an impact on objectives. A risk may have a positive or negative impact. Risk is measured in terms of a combination of the consequences of an event and their likelihood and is often specified in terms of an event or circumstance and the consequences that may flow from it.

Risk analysis

A systematic process to understand the nature of and to deduce the level of risk that provides the basis for risk evaluation and decisions about risk treatment.

Risk assessment

The overall process of risk identification, risk analysis and risk evaluation.

Risk avoidance

A decision not to become involved in, or to withdraw from, a risk situation.

Risk criteria

The terms of reference by which the significance of risk is assessed. Risk criteria can include associated cost and benefits, legal and statutory requirements, socioeconomic and environmental aspects, the concerns of stakeholders, priorities and other inputs to the assessment.

Risk evaluation

A process of comparing the level of risk against risk criteria. Risk evaluation assists in decisions about risk treatment.

Risk identification

The process of determining what, where, when, why and how something could happen.

Risk management

The culture, processes and structures that are directed towards realizing potential opportunities whilst managing adverse effects.

Risk management process

The systematic application of management policies, procedures and practices to the tasks of communicating, establishing the context, identifying, analysing, evaluating, treating, monitoring and reviewing risk.

Risk management framework

A set of elements of an organisation's management system concerned with managing risk. Management system elements can include strategic planning, decision making, and other strategies, processes and practices for dealing with risk. The culture of an organisation is reflected in its risk management system.

Risk reduction

Actions taken to lessen the likelihood, negative consequences, or both, associated with a risk.

Risk retention

The acceptance of the burden of loss, or benefit of gain, from a particular risk. Risk retention also includes the acceptance of risks that have not been identified. The level of risk retained may depend on risk criteria.

Risk sharing

Sharing with another party the burden of loss, or benefit of gain from a particular risk. Legal or statutory requirements can limit, prohibit or mandate the sharing of some risks. Risk sharing can be carried out through insurance or other agreements. Risk sharing can create new risks or modify an existing risk.

Risk treatment

Process of selection and implementation of measures to modify risk. The term 'risk treatment' is sometimes used for the measures themselves. Risk treatment measures can include avoiding, modifying, sharing or retaining risk.

Standards

Generally referring to the use of Australian Standards.

2. Risk Management Process

2.1 Overview

This section provides a brief overview of the risk management process. Risk management has been described as a process consisting of well-defined steps which, taken in sequence, support better decision making by contributing a greater insight into risks and their impacts (AS:4360:2004).

Risk management can be applied at many levels with an organisation from strategic to operational levels. It can be applied to a business unit (such as maintenance) or a single process (transport of coal). Risk management can also be applied to specific projects (such as shut downs) or manage a specific recognised risk (electrocution or explosion). It is important that the management of risk is an integral part of the management process and not just an add on.

Risk management aims to reduce the likelihood and impact of mishaps of all kinds. In the mining industry, with its inherent potential for major accidents which could injure or kill many people, damage the environment, cause serious loss of production and hence profit, there is a particular need for a sound approach to the process of risk management.

Risk management identifies:

- which risks are most in need of reduction, and the options for achieving that risk reduction; and
- which risks which need careful on-going management, and the nature of that on-going attention

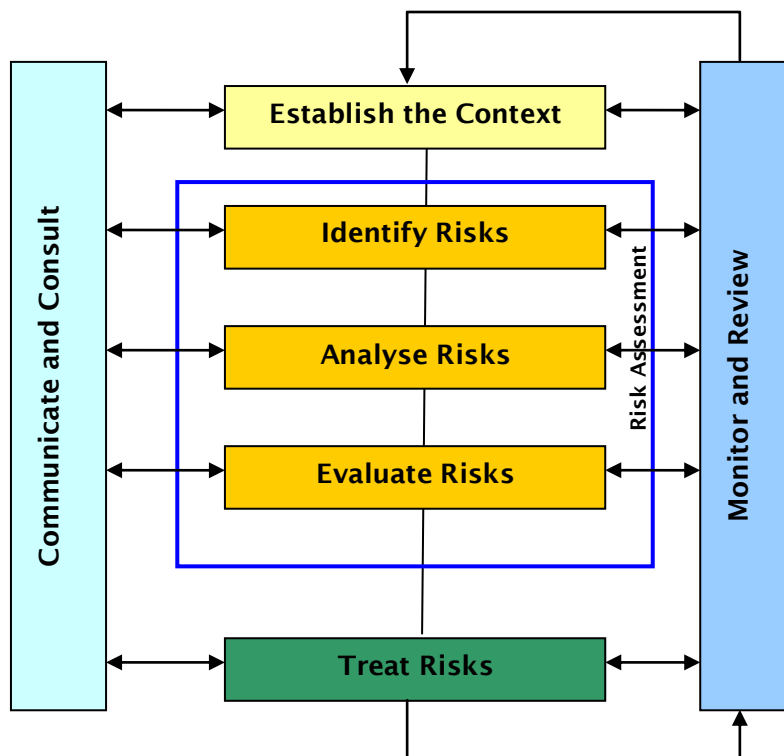
2.2 The Risk Management Framework

The main elements of the risk management process, as shown in Figure 1 below, are the following:

- a.) Establish the context - This step establishes the strategic, organisational and risk management context in which the rest of the process will take place. Criteria against which risk will be assessed are established and the structure of the analysis is defined.
- b.) Identify risks - Identify what, why and how events can arise and could cause harm as the basis for further analysis
- c.) Analyse risks - Determine the existing controls and analyse risks in terms of likelihood and consequence in the context of those controls. The analysis should consider
 - (i) how likely is an event to happen; and
 - (ii) What are the potential consequences and their magnitude?
 - (iii) Combine these elements to produce an estimated level of risk.

- d.) Evaluate risks - Compare estimated levels of risk against the pre-established criteria. Risks are then ranked to identify priorities. If the levels of risk established are low, then risks may fall into an acceptable category and treatment may not be required.
- e.) Treat risks - Develop and implement specific controls and management plans for identified priorities. Accept and monitor low-priority risks.
- f.) Monitor and Review - All steps in the risk management process should be monitored and subject to review. For each stage adequate records should be kept to demonstrate how decisions were made and what was the outcome of the process.

Figure 1: Risk Assessment Process



Source: AS/NZS 4360:2004 Risk Management

Key questions associated with the seven phases of the risk management process:

Phase

Establish the context
 Risk Identification
 Risk Analysis

 Risk Assessment
 Risk Treatment
 Monitoring and Review
 Communicate and Consult

Question

What are we looking at?
 What could go wrong?
 What might that mean for the mine or process?
 Which are the most important problems?
 How can they be managed?
 How do we ensure they stay managed?
 Who do we need to ask and keep informed?

3. Establish the context

3.1 Overview

Establishing the context defines the limit within which risks must be managed and sets the scope for the rest of the risk management process. The context includes the organisation's external and internal environment and the purpose of the risk management activity.

It is important to ensure that the objectives defined for the risk management process take into account the organisational and external environment. If they are not the risk management process may be incomplete and basic assumptions that underpin the process may be wrong.

Understanding all of the stakeholders in the risk management process and their impact on risk management assists in understanding the context of the risk management process.

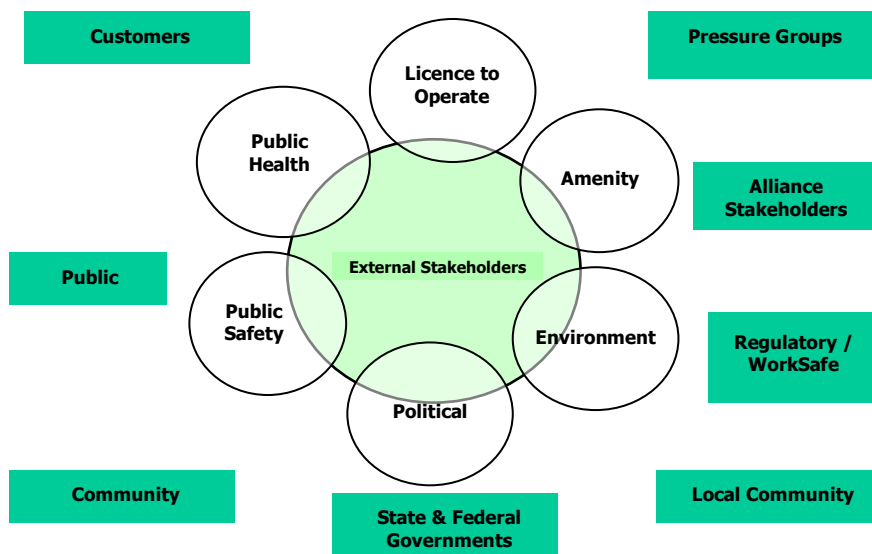
3.1.1 Establish the external context

This step defines what external impacts there are on the organisation. This may, for example, include:

- The business, social, regulatory, cultural, competitive, financial and political environment;
- The organisation's strengths, weaknesses, opportunities and threats;
- External stakeholders; and
- Key business drivers.

Establishing and documenting the external context is important to ensure that stakeholders and their objectives are considered when developing risk management criteria and that externally generated threats and opportunities are properly taken into account.

Figure 2: External Risk Management Context



Source: Adapted from Jameson and Purdy (2001)

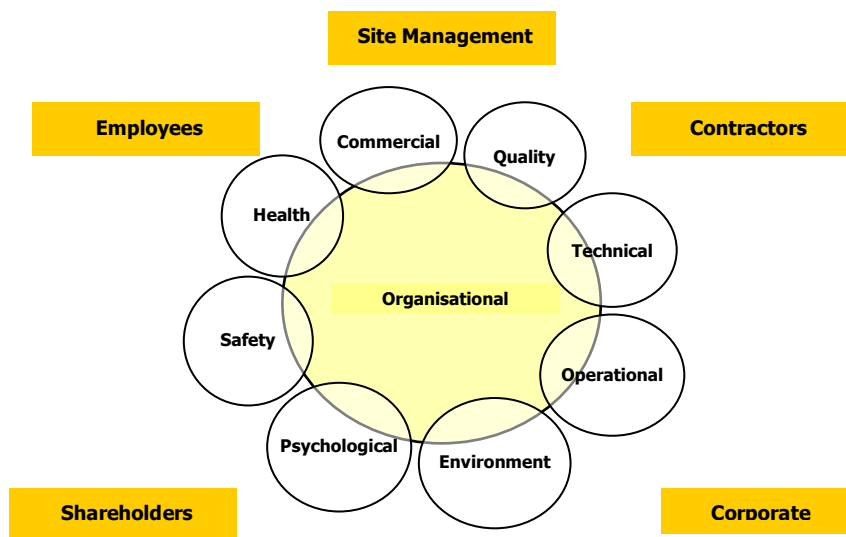
3.1.2 Establish the internal context

Before a risk management activity, at any level, is commenced, it is necessary to understand the organisation. Key areas include:

- Culture;
- Internal stakeholders;
- Structure;
- Work methods;
- Mining methods;
- Capabilities in terms of resources such as people, systems, processes; and
- Goals and objectives and the strategies that are in place to achieve them.

Establishing the internal context is important because risk management does not occur in a vacuum. Risk management occurs in the real world with people, problems, existing systems and these must be taken into account.

Figure 3: Internal Risk Management Context



Source: Adapted from Jameson and Purdy (2001)

3.1.3 Establish the overall risk management context

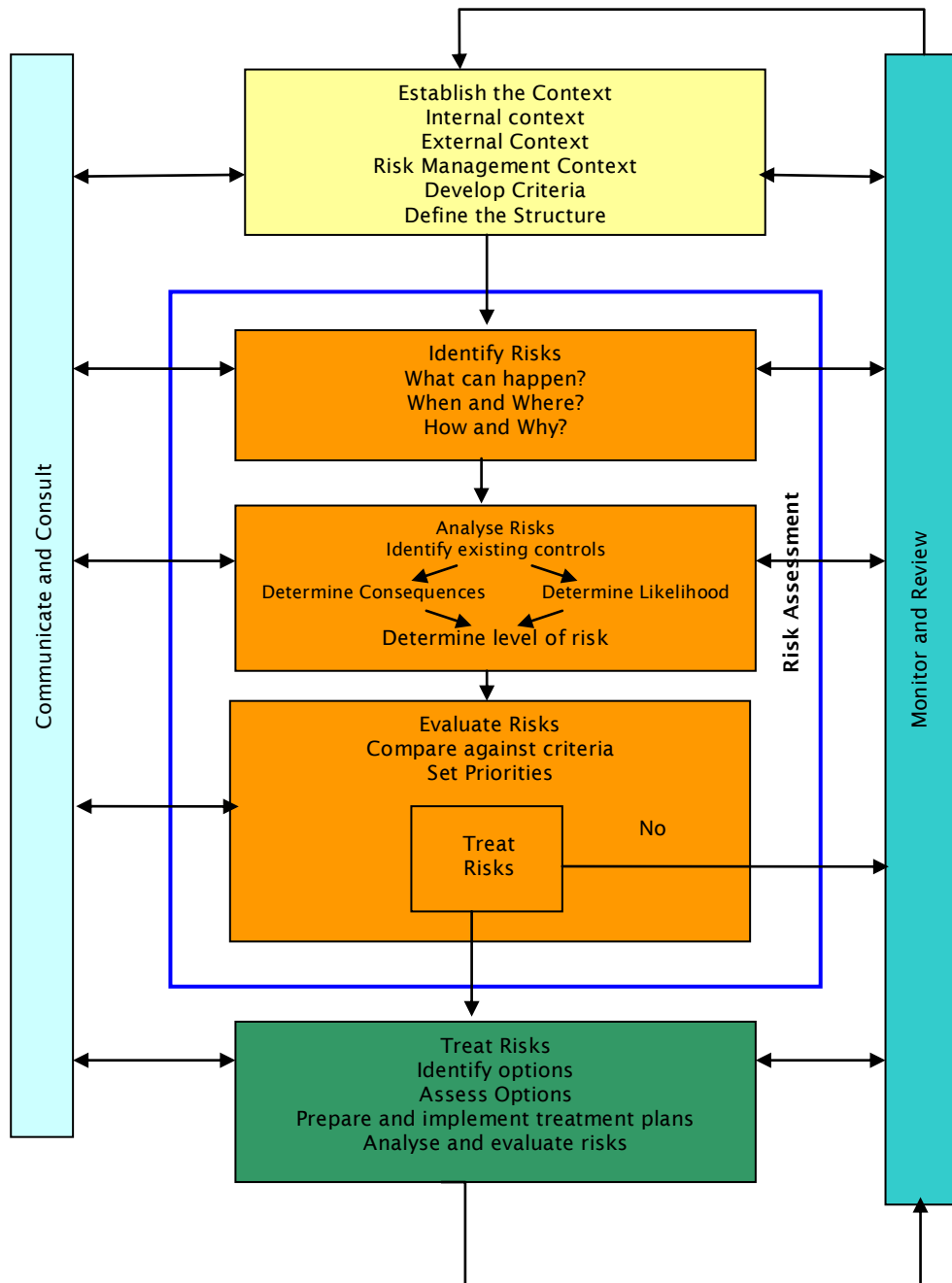
This involves defining and recording:

- The goals of the risk assessment study;
- The scope and limits to the risk assessment process;
- Defining clearly the process, task or work method under assessment;
- The specific nature of the risk assessment;
- Inclusions and exclusions; and
- Basic assumptions used.

3.1.4 Define the structure for the rest of the process

This involves subdividing any activity, process, project or change into a set of elements or steps in order to provide a logical framework that helps ensure significant risks are not overlooked. The structure chosen depends on the nature of the risks and the scope of the project, process or activity. A detailed overview of the risk management process follows.

Figure 4: Risk Management Process in Detail



Source AS/NZS 4360:2004 Risk Management

4. Hazard Identification

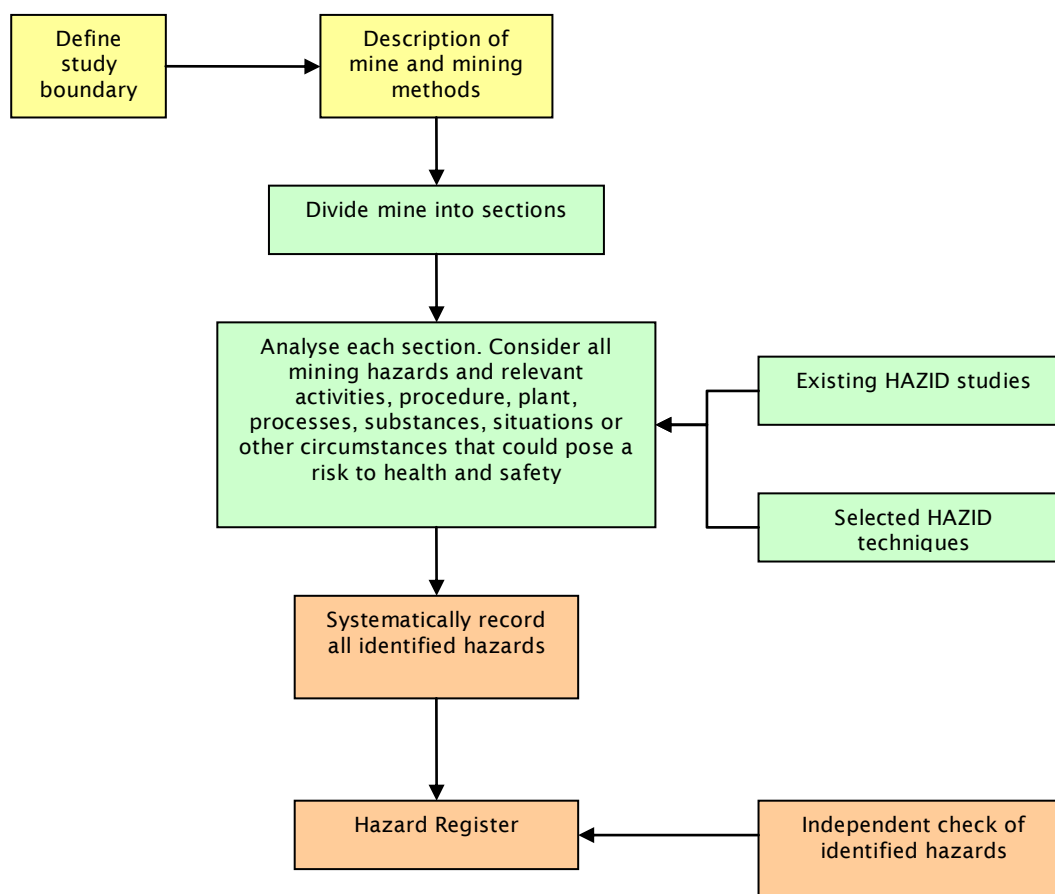
4.1 Overview

Once the context of the risk assessment has been properly documented the next step in the risk management process is to identify the hazards associated with any mining activities under consideration. The outcome of this hazard identification process should be a comprehensive and creditable list of health and safety risks associated with the mining activities being assessed. An accurate and full listing of hazards is critical as it forms the basis of future risk management activities.

The documentation of the hazard identification (HAZID) process should include the purpose and scope of the hazard identification, listing of appropriate personnel, HAZID tools and resources used. Sufficient time should be allocated for the hazard identification process and the reporting processes should be defined.

An accurate description of the system of work, methods, assets, materials, human activities and process operations should be clearly defined and understood by the participants. The description may divide a process into sections or the mine into distinct separate activities, locations, or sections, to enable manageable quantities of information to be handled at each stage. The overall hazard identification process for a mine wide assessment is summarised below

Figure 5: Overview of Mine Wide Hazard Identification Process.



Appropriate background information and studies should be collated including historical incident data before commencing the hazard identification process. This also includes all necessary diagrams, mining information, and existing conditions. Check lists can be prepared to assist with the identification of hazards and to save time. This information can be used to check assumptions, highlight issues and ensure that the hazard identification process is comprehensive.

Having identified what might happen, it is also necessary to consider possible causes and scenarios. There are many ways an event can occur. It is important that no significant causes are omitted during the hazard identification process. Comprehensive hazard identification using a well-structured systematic process is critical, because a risk not identified at this stage may be excluded from further analysis.

Figure 6: Conveyor Guarding and Access Hazards



What are the health and safety hazards in this scenario?

4.2 *When should Hazard Identification (HAZID) be conducted?*

A hazard identification process should be conducted:

- Prior to the commencement of mining operations;
- Before a modification to the mine is undertaken because physical changes to the mine may introduce new hazards;
- If a change to the workforce is introduced that could lead to changes in work practices, or in knowledge of the mine is introduced;
- On a regular basis to ensure risk controls and OHS systems are effective;
- As part of a review of previously identified hazards which may be necessary before certain activities are carried out, particularly ones performed rarely;
- If abnormal conditions arise e.g. during the shut down of the mine; or
- As part of incident or near miss investigations to consider whether additional hazards are now present and if current controls are adequate.

4.3 Hazard Identification Process

The hazard identification process should move progressively through the process or the mining activity being studied, recording its operations and associated mining hazards and applying the HAZID tools or checklists to each process or section in turn. At this stage all identified hazards and incidents should be recorded. It may be useful to use a checklist of guide words, questions or issues; for example:

- What is the broad range of mining activities or operations being conducted on the site?
- What mining activities occur that could cause or contribute towards mining hazards and incidents (e.g. operations, maintenance, transport, processing)?
- For each mining hazard: what are the relevant activities, procedures, plant, processes, substances, situations or other circumstances that could pose a risk to health and safety?
- Have mining hazards for the full range of operational situations been identified:
 - Normal operations / shut down / care and maintenance
 - Emergency situations
 - Any other abnormal conditions
- What could happen to create additional hazards? Have mining hazards regarding changes to current conditions and operational situations been identified?
 - Changes to the mine design (original and planned)
 - Changes to the mining method
 - Increased or reduced through put
 - Increased or reduced manning
 - Material or equipment changes
- Are all of the mining hazards as listed in the health and safety legislation relevant to your particular site? If not why not?

Figure 7: Plant and Equipment Maintenance Hazards



What are the potential health and safety hazards in this scenario?

4.4 Hazard Identification Tools

There are numerous available hazard identification techniques, each of which may be useful in particular circumstances. While there is no single method which is the correct one for any particular situation the facilitator should consider the nature of the mine, and select the most appropriate combination of techniques to ensure that a robust and comprehensive list of hazards and incidents are identified.

Checklists

There are many established hazard checklists, each of which (or a combination) can be used to guide the identification of hazards. These offer straightforward and effective ways of ensuring the basic types of event are considered. However, it should be noted that checklists are rarely sufficient on their own, as they may not cover all types of hazard, particularly mine-specific hazards, and they tend to suppress discussion and any lateral thinking.



Historical records of incidents

Databases of incidents and near misses are a useful reference because they give a very clear indication of how incidents can actually arise. A HAZID should consider site history, company history, industry history and possibly even wider sources of historical information for this purpose. However, historical data alone cannot be relied on, as the range of events that has actually occurred may not be the entire range of possible events.



What-if Techniques

This is typically a combination of the above techniques, often using a prepared set of 'what-if' questions on potential deviations and upsets in the facility. This approach is broader but less detailed than a Hazard and Operability Study (HAZOP). For example "what if a haul truck has too much speed coming down a ramp?"



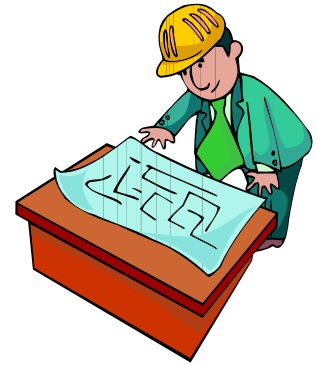
Brainstorming

This is typically an unstructured or partially structured group process, which can be effective at identifying obscure hazards of a type that may be overlooked by the more systematic methods. The aim of the brain storming session is to cover all potential risks without making judgements about the importance in the initial stages of the risk assessment process.



Task Analysis

This is a technique developed to address human factors, procedural errors and so-called 'man-machine interface' issues. This type of hazard identification is useful for unearthing potential problems relating to procedure failures, human resources, human errors, fault recognition, alarm response, etc. Task analysis can be applied to specific jobs such as lifting operations or bringing equipment off-line, or to specific working environments such as control rooms. Task analysis is particularly useful for looking at areas of a facility or process where there is a low 'fault-tolerance', where human error can easily take a plant out of its safe operating envelope. Job Safety Analysis is a form of Task analysis.



4.5 Detailed Hazard Identification Tools

Fault and Event Tree Analysis

Fault trees describe an incident (e.g. loss of containment) in terms of the combinations of underlying failures that can cause them (such as a control system upset combined with failure of alarm, shutdown and relief systems). Event trees describe the possible outcomes of a hazardous event, in terms of the failure or success of reduction and mitigation measures such as isolation and fire fighting systems.

Fault-tree and event-tree analysis is time-consuming, and it may not be practicable to use these methods for more than a small number of incidents. However, the methods have the advantage that they include control measures in a transparent way, and they can be reformatted into the 'bow-tie' concept.

HAZOP

Hazard and Operability Study is a highly structured and detailed technique, developed primarily for application to chemical process systems, which generates a comprehensive understanding of the possible 'deviations from design intent' which may occur. As well as purely operational problems, these process deviations may include hazards and potential major incidents.

However, HAZOP is less suitable for identification of hazards not related to process operations, such as mechanical integrity failures, procedural errors, or external events. HAZOP also tends to identify hazards specific to the section being assessed, while hazards related to the interactions between different sections may not be identified. Hence, HAZOP may need to be combined with other hazard identification methods, or a modified form of HAZOP used, in order to overcome these limitations.

FMECA

Failure Modes, Effects and Criticality Analysis. This is a highly structured technique, usually applied to a complex item of mechanical or electrical equipment. The overall system is described as a set of sub-systems, and each of these as a set of smaller sub-systems, and so on down to component level. Individual system, sub-system and component failures are systematically analysed to identify their causes (which are failures at the next lower-level system), and to determine their possible outcomes (which are potential causes of failure in the next higher-level system).

4.6 Hazard Identification Team

A Hazard Identification process should not just be conducted by an organisation's safety specialists or external consultants. Health and safety representatives should be consulted on all aspects of the hazard identification, risk assessment and control.

In addition to health and safety representatives all relevant work groups involved in different aspects of safe operation of the mine should be included in the hazard identification process. This includes: operations, maintenance, engineering, human resources, contractors, etc. Such a spread of work groups (horizontal) gives a HAZID adequate breadth of coverage. As well as different work groups all levels of the organisation (miners, plant, operators, supervisors, and managers) should be involved in the HAZID process. This involvement is often called a vertical slice of the workforce.

By involving different workgroups and all levels of the organisation this will give the HAZID sufficient breadth and depth because each work group and level will tend to bring a different knowledge base and perspective, and will tend to identify different types of hazard usually related to their area of work.

Figure 8: Hazard Identification Team in the Workshop



In addition, it is often found that certain hazards which are not evident to individual work groups, are identified as a result of combining the knowledge of specialists in different groups, because those hazards arise from the interactions (or breakdowns) between different groups.

For example, a change in materials procurement may not have been fully worked through or communicated with maintenance and operations staff, creating a potential additional hazard.

Once the participants in the HAZID are selected, the facilitator should test whether there is enough experience and different knowledge to conduct the assessment.

Employees must be suitably trained in the relevant HAZID methodologies so that they can fully participate in the process. Active involvement of employees in HAZID is essential, particularly in relation to the need to understand actual practices, deviations that may occur from standard procedures, and 'near-misses' which have already occurred or may be continuing to occur.

In developing a process for a HAZID it is important to consult with health and safety representatives, to ensure that the appropriate people are involved in carrying out HAZID, and that the approaches used are suitable for these people.



Following completion of HAZID, the results must be provided to employees in the form of information, instruction or training. This will ensure that all employees have sufficient knowledge of the hazards to enable them to carry out their roles safely, regardless of whether they were involved in the HAZID itself.

Key Points

Roles should be developed for employees to be involved in hazard identification and should involve different workgroups and all levels of the organisation in the HAZID process.

The mine management must provide information and feedback to the health and safety representatives and employees regarding the findings of the HAZID.

4.7 Hazard Identification Report

The hazard identification process should be clearly documented and should include:

- The date (s) of the HAZID;
- Listing of personnel involved (name and operational positions);
- Statement as to the training or competence of persons undertaking the identification;
- Purpose and scope of the hazard identification process;
- Summary of the context of the hazard identification process;
- Description of the mine;
- Description of the mining method and what is mined;
- Description of the organisation (staffing levels, shift patterns, rosters etc);
- Descriptions of all major equipment used;
- Whether a site inspection was conducted as part of the identification of hazards;
- Explanation of the HAZID methodology used;
- Listing of any definitions or acronyms;
- Listing of documents used (checklists incident, records, industry codes etc);
- Listing of maps, diagrams and plans used;
- Reference to appropriate Codes of Practice and Standards used;
- A comprehensive report listing the hazards identified;
- Thorough descriptions of each hazard;
- The location of each hazard; and
- It is recommended each hazard is given a unique identifying number

4.8 Critical Success Factors

The hazard identification process should be:

- Based on all relevant information and experience and use appropriate practicable techniques for hazard identification;
- Systematic and structured. It must be fully and transparently documented (including methods, criteria, assumptions and results) such that other parties may review these factors; and
- Robust, appropriate and timely in relation to the facility.

The detail and effort associated with the hazard identification process should correspond with the level of complexity of the mine, and the mining methods

The hazard identification process should also

- Use tools and people appropriate to the nature of the plant and the operations being analysed;
- Use the expertise and knowledge of health and safety representatives, employees, technical staff and experts; and
- Clearly define each mining hazard.

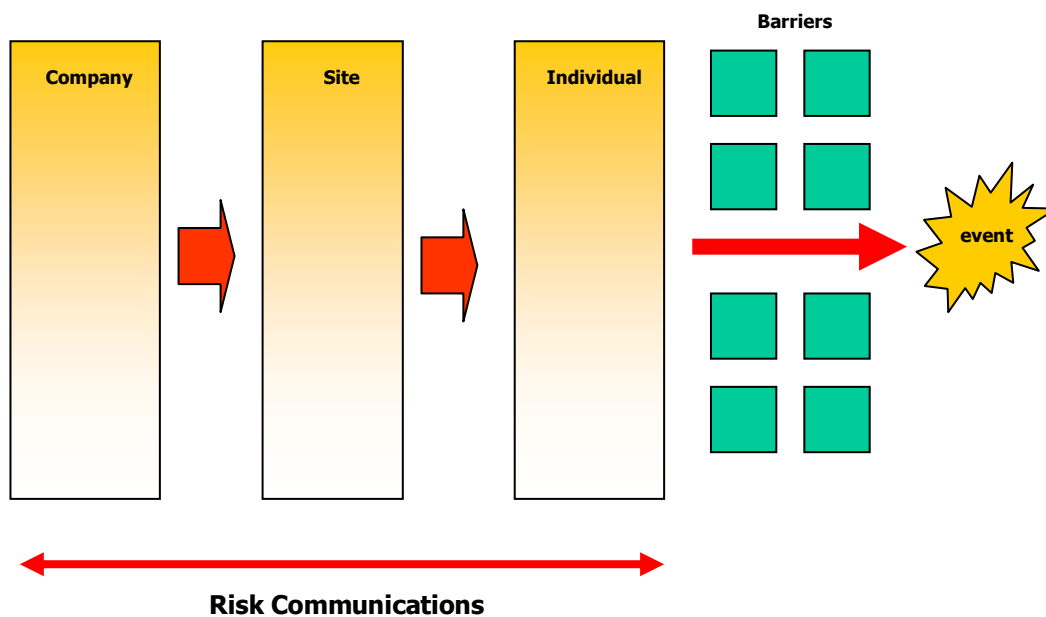
5. Introduction to Risk Assessment

Once all mining hazards at a mine or the hazards associated with a particular task or process have been identified an assessment of risks to health and safety can be undertaken. “Risk assessment” is the systematic process of assessing the:

- The likelihood of the mining hazard causing, or contributing to, any harm to any person; and
- The severity of the harm that may be caused.

These health and safety risks can be considered or assessed at various levels within an organisation depending on the scope and purpose of the assessment:

- Company level (or corporate risk)
- Site level (whole of mine)
- Individual (task or personal)



Source: Adapted from (Reason 1997)

5.1 Preparation

Thorough preparation for a risk assessment is critical. A poorly planned and executed risk assessment process will not only damage the credibility of the risk assessment but also potentially the reputation of the facilitator and the organisation.

Therefore the purpose and scope of the risk assessment should be agreed prior to commencement the appropriate personnel that will be involved and the risk assessment tools that will be used.

Participants should be informed of the date, time and venue. They should also be told of the purpose of the risk assessment and the task or activity being assessed and if they need to bring any plans, diagrams or reports to assist the process.

The reporting processes should be clearly defined and a scribe and facilitator should be appointed prior to the assessment. Clear risk assessment boundaries should be defined, according to the purpose and scope and appropriate background information and studies including, the outputs from any previous HAZID should be available.

If clear boundaries are not defined there is a risk that the assessment process will become bogged down in detail or unnecessary discussion about the purpose and nature of the assessment may occur wasting valuable time.

If a whole of mine risk assessment is being undertaken, then the risk assessment may use the approach of dividing the mine into distinct separate activities, processes, locations, or sections to enable manageable quantities of information to be handled at each stage.

5.2 Adopting a Systematic Approach

The overall risk assessment process must be conducted using appropriate and recognised methodologies. Each mine should use a risk assessment process (specific tools and techniques) which are appropriate or one that is required by specific legislation. At a minimum, the risk assessment process used should conform to the methodology contained *Australian Standard 4360: Risk Management*.

The risk assessment should move progressively through the hazards recording the likelihood of the hazard causing, or contributing to, any harm to any person and the severity of the harm that may be caused. The results of the risk assessment must be properly documented. As discussed previously, the assessment should involve a range of employees who have knowledge of relevant aspects of the mine.

During the assessment pre-existing HAZID studies may be referred to, and used if they are appropriate. However, any existing studies used must fully be understood by the HAZID participants and any gaps in the studies addressed.

It is critical that previous studies are not relied upon too much as they may have become inaccurate or incomplete. Primarily this is because they may have been based on different underlying assumptions. Applicable legislation, standards and knowledge may have also changed. This may mean that they are not as comprehensive or up to date as they should be. At best they should only be used as a guide and a reference point.

5.3 *Selecting a risk assessment method*

There are numerous risk assessment techniques available, each of which may be useful in particular circumstances. While there is no single method which is the correct one for any particular situation, the facilitator should consider the nature of the mine, and select the most appropriate combination of techniques to ensure that a robust and comprehensive risk assessment is conducted.

When selecting a risk assessment method to use, you and the team may need to take into account:

- Any existing corporate risk assessment methodologies;
- The nature of the risks or task being assessed;
- Legislative requirements (is there a method that is mandated by health and safety legislation);
- The level of expertise within the organisation to support and participate in the risk assessment process; and
- The amount of time available for the assessment.

You may also wish to ask the question “will a more complex or detailed risk assessment process reveal any more useful information than a simple but thorough one?”

Generally however, for risks that are hard to quantify, or for a quick initial analysis, qualitative or descriptive models are suitable and for technical hazards, detailed calculations and fault tree analysis may be required.

Once a method is selected you should ensure that it has is a clear method statement or description of the risk assessment process, defining when a risk assessment is carried out. How it is planned and prepared for, who is involved and what tools and resources are employed to undertake the process should also be documented.

5.4 *Risk Assessment Team*

The risk assessment process should not just be conducted by an organisation's safety specialists or external consultants. The management of a mine should consult with the employees or with agreed representatives of the employees on all aspects of the risk control.

In addition to health and safety representatives, all relevant work groups involved in different aspects of safe operation of the mine should be included in the risk assessment process: operations, maintenance, engineering, human resources, contractors, etc. Such a spread of work groups (horizontal) gives the risk assessment process adequate breadth of coverage. As well as different work groups all levels of the organisation (miners, plant, operators, supervisors, and managers) should be involved in the risk assessment process. This involvement is often called a vertical slice of the workforce.

By involving different workgroups and all levels of the organisation this will give the risk assessment process sufficient breadth and depth because each work group and level will tend to bring a different knowledge base and perspective, and will tend to identify different types of risks usually related to their area of work.

In addition, it is often found that certain risks which are not evident to individual work groups, are identified as a result of combining the knowledge of specialists in different groups, because those hazards arise from the interactions (or breakdowns) between different groups.

For example, a change in materials procurement may not have been fully worked through or communicated with maintenance and operations staff, creating a potential additional hazard. Once the participants in the HAZID are selected, the facilitator should test whether there is enough experience and different knowledge to conduct the assessment.

Figure 9: Potential Electrical Hazard



What are the potential health and safety hazards in this scenario?

Employees must be suitably trained in the relevant risk assessment methodologies so that they can fully participate in the process. Active involvement of employees in risk assessment is essential, particularly in relation to the need to understand actual practices, deviations that may occur from standard procedures, and 'near-misses' which have already occurred or may be continuing to occur.

In undertaking a risk assessment it is important to consult with health and safety representatives, to ensure that the appropriate people are involved in carrying out risk assessment, and that the approaches used are suitable for these people.

Following completion of risk assessment, the results should be provided to employees in the form of information, instruction or training. This will ensure that all employees have sufficient knowledge of the hazards to enable them to carry out their roles safely, regardless of whether they were involved in the risk assessment itself.

As a guide a risk assessment team should include at a minimum:

- People undertaking the tasks;
- Health and Safety representatives (if available);
- A supervisor of the person undertaking the tasks;
- The OHS advisor / manager;
- Someone who is familiar with the task and has technical expertise work;
- Method and equipment;
- Management representatives; and
- A facilitator who is familiar with the risk assessment methods to be used

5.5 *Recording the Process*

The process used to assess the risk and the results of the risk assessment should be properly documented. This should include at minimum:

- The date of the assessment and the names and positions of the team assessing the risks;
- Brief statement as to the training or competence of persons undertaking the assessment;
- Purpose and scope of the risk assessment;
- Summary of the context of the risk assessment process;
- Description of the mine;
- Explanation of the assessment methodology used;
- Listing of any definitions or acronyms;
- Listing of documents used (checklists incident, records, industry codes etc);
- Listing of maps, diagrams and plans used;
- Reference to appropriate Codes of Practice and Standards used;
- Description of the mining method and what is mined;
- Description of the organisation (staffing levels, shift patterns, rosters etc);
- Descriptions of all major equipment used;
- Whether a site inspection was conducted as part of the risk assessment;
- A full description or nature of the mining hazard;
- A description of the likelihood of the mining hazard causing, or contributing to, any harm to any person;
- A description of the consequences of the mining hazard; and
- Control measures



5.6 *Communicate and consult.*

Communication and consultation are important considerations at each step of the risk management process. Early and frequent communication to the participants and stakeholders is important. Stakeholders need to understand the basis on which decisions are made and why particular actions are required. Since the views of stakeholders can have a significant impact on the decisions made, it is important that their perceptions are identified and taken into account during any decision making processes.

If people are well informed they are more likely to become involved in the risk assessment process; understand the outcomes and take ownership of actions. If communication is poor, people may become suspicious and distrustful of the process.

For the facilitator this means communicating:

- Why a risk assessment is required;
- Who is involved;
- How it will be done;
- What the results are;
- What will happen now; and
- How will it affect relevant people?



Communication and involvement also allows the 'ownership' of risk by managers and the engagement of stakeholders. It allows them to appreciate the benefits of particular controls and the need to endorse and support a treatment plan.

If the risks are complex or controversial, you may wish to develop a communication plan for both internal and external stakeholders at the earliest stage of the process. This plan should address issues relating to both the risk itself and the process to manage it.

Records of communication and consultation will depend on factors such as legislative requirements and the scale and the sensitivity of the activity being assessed. However, recording communication and consultation is encouraged for all risk assessment activities as it demonstrates that both have been done.

6. Risk Assessment - Process

6.1 Overview

The analysis of risk involves understanding the nature of the hazard; the nature of existing controls and recovery measures; assessing the likelihood of the hazard occurring; and the severity of its consequences should it occur.

The various methods available for risk assessment generally use the same broad principles. Consequences and likelihood are identified and combined to produce a level of risk. Consequences and likelihood may be estimated using statistical analysis and calculations if reliable data or statistics are available. Some risk assessment methods use a combination of consequences x exposure x probability (*AS 4804 Occupational Health and Safety Management Systems - General Guidelines and principles, systems and supporting techniques*).

Where there is no reliable or relevant past data, subjective estimates can be used which reflect an individual's or group's belief that a particular event or outcome will occur. Only the most relevant information sources and techniques should be used when analysing consequences and likelihood.

Key point: When assessing the likelihood and consequences of a risk to determine a risk level it is important that the assessment is robust and that all participants in the risk assessment are heard and their views considered. No one person should be allowed to dominate or unduly influence the discussion.

Valuable sources of information regarding likelihood and consequences of an event can include the following:

- Past records;
- Practice and relevant experience;
- Relevant published literature;
- Market research;
- The results of public consultation;
- Experiments and prototypes;
- Economic, engineering or other models; and
- Specialist and expert judgments.

Techniques for assessing the consequences and likelihood of an event can include:

- Structured interviews with experts in the area of interest; use of multi-disciplinary groups of experts;
- Individual evaluations using questionnaires; and
- Use of models and simulations.

Key point: All assumptions made in the analysis the consequences and likelihood of an event should be clearly stated.

6.2 *Types of Analyses*

Risk analysis may be undertaken to varying degrees of detail depending upon the nature and severity of the risk, the purpose of the analysis, and the information, data and resources available. Analysis may be qualitative, semi-quantitative or quantitative or a combination of these, depending on the circumstances.

The order of complexity and costs of these analyses, in ascending order, is qualitative, semi-quantitative and quantitative. “Qualitative Analysis” uses word form or descriptive scales to describe the likelihood and the severity of the mining hazard being assessed. In practice, qualitative analysis is often used first to obtain a general indication of the level of risk and to reveal the major risk issues.

Later it may be necessary to undertake more specific or quantitative analysis on the major risk issues.

In “Semi-quantitative Analysis”, qualitative scales are given values. The number allocated to each description does not have to bear any accurate relationship to the actual magnitude of the severity or likelihood.

“Quantitative Analysis” uses numerical values (rather than descriptive scales used in qualitative and semi-qualitative analysis) for both the severity and likelihood using data from a variety of sources.

6.2.1 Qualitative

Qualitative analysis uses words to describe the magnitude of potential consequences and the likelihood that those consequences will occur. These scales can be adapted or adjusted to suit the circumstances, and different descriptions may be used for different risks. Qualitative analysis may be used:

- As an initial screening activity to identify risks which require more detailed analysis;
- Where this kind of analysis is appropriate for decisions; or
- Where the numerical data or resources are inadequate for a quantitative analysis.

Qualitative analysis should be informed by factual information and data where available.

6.2.2 Semi Quantitative

In semi-quantitative analysis, qualitative scales such as those described above are given values. The objective is to produce a more expanded ranking scale than is usually achieved in qualitative analysis, not to suggest realistic values for risk such as is attempted in quantitative analysis.

However, since the value allocated to each description may not bear an accurate relationship to the actual magnitude of consequences or likelihood, the numbers should only be combined using a formula that recognizes the limitations of the kinds of scales used.

In a dynamic mining environment semi-quantitative risk assessment is commonly used. However care must be taken with the use of semi-quantitative analysis because the numbers chosen may not properly reflect relativities and this can lead to inconsistent or inappropriate outcomes. Semi-quantitative analysis may not differentiate properly between risks, particularly when either consequences or likelihood are extreme.

6.2.3 Quantitative

Quantitative analysis uses numerical values (rather than the descriptive scales used in qualitative and semi-quantitative analysis) for both consequences and likelihood using data from a variety of sources. The sources of data used in a quantitative study can be drawn from such sources as industry frequency tables and manufactures data. The quality of the analysis depends on the accuracy and completeness of the numerical values and the validity of the models used.

Consequences are usually determined by modelling the outcomes of an event or set of events, or by using past data. The way in which consequences and likelihood are expressed and the ways in which they are combined to provide a level of risk will vary according to the type of risk and the purpose for which the risk assessment output is to be used.

The uncertainty and variability of both consequences and likelihood should be considered in the analysis and communicated effectively.

Sensitivity analysis

Since some of the estimates made in risk analysis are imprecise, a sensitivity analysis may be carried out to test the effect of uncertainty in assumptions and data. Sensitivity analysis is also a way of testing the appropriateness and effectiveness of potential controls and risk treatment options.

For example you may increase or decrease the consequences or probability of a risk event. This can then be discussed within the group testing the original logic and assumptions of the group.

6.3 Evaluate Risks

Once the risk (or all risks) being considered have been analysed they need to be evaluated. The purpose of risk evaluation is to make decisions, based on the outcomes of risk analysis, about which risks need treatment and what are the treatment priorities.

Generally this step involves ranking all risks into a consolidated listing (risk register) with all identified and assessed risks ranked highest to lowest.

Decisions should take account of the wider context of the risk and include consideration of legal, moral, financial and ethical requirements. In some circumstances, the risk evaluation may lead to a decision to undertake further analysis.

Figure 10: Unlabelled fluid bottles



What are the potential health and safety hazards and risks in this scenario?

6.4 Treat Risks

6.4.1 General

Risks must be treated in accordance with relevant legislation and Standards. Risk treatment involves identifying the range of options for treating risks, assessing these options and the preparation and implementation of treatment plans.

6.4.2 Identifying options for the treatment of risks

There may be many ways in which a particular risk can be controlled. The organisation will have to decide which method is the most appropriate and which complies with relevant legislation. The identification of options for the treatment of risks is best undertaken by a multi disciplinary group involving persons who undertake the task where the risk is involved and technical specialists who are able to apply their skills and knowledge to the issue.

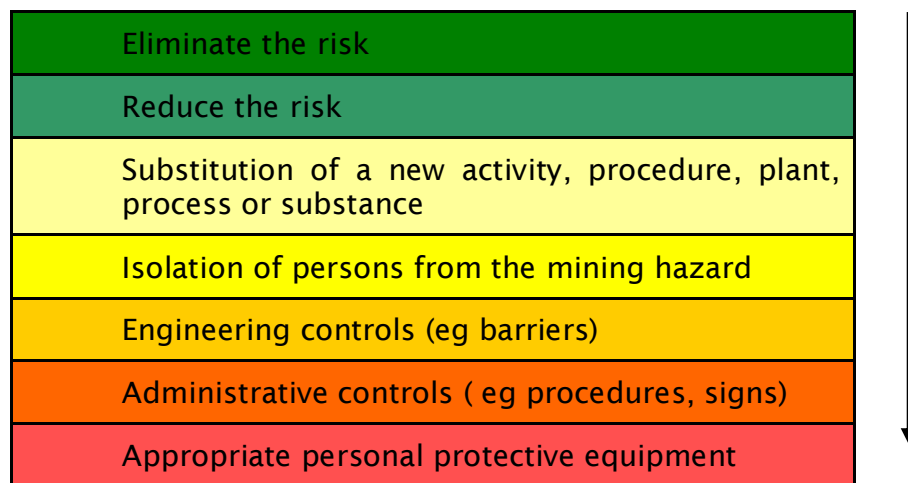
The identification of control options should be a free flowing discussion (brainstorming exercise) where no controls are discounted at this point. All control options should be recorded and participants in the identification phase should be encouraged to think of as many different controls as they can. The assessment of the viability of the controls will be conducted later.

When identifying controls you must ensure that you have considered the risk management context (including legal requirements). Some controls (or requirements such as noise levels or particulate concentrations) may be mandated by law and therefore are not negotiable.

A number of options may be considered and applied either individually or in combination. For example where the elimination or reduction of noise on mine site to a safe level is not possible. Procedures, signage, exclusion zones, training and personal protective equipment may be provided to ensure the health and safety of employees. This is also an example where multiple controls are used to reduce the risks associated with a hazard.

Most performance based health and safety legislation requires risks to be eliminated at its source. The “hierarchy of control” details the preferred order of control measures for OHS risks. The higher in the hierarchy of control, the better and more reliable the control is. The hierarchy of control is listed below.

Figure 11: Hierarchy of Control



Source: Office of the Australian Safety and Compensation Council

When deciding on the best way to control a risk, start at the top of the hierarchy of controls, i.e. investigate if the risk can be eliminated first, for example by changing the way the work is done to eliminate the risk or equipment. This is the most effective way to control a hazard. If these methods are not possible, use engineering or administrative controls to reduce or minimise the risk.

Codes of Practice, Australian Standards, Compliance Codes and Industry Publications may provide additional guidance or checklists regarding appropriate ways to reduce or minimise the risk.

Control Matrix

Organisations may also use a control development matrix as an aid or checklist to assist in the development of controls. The matrix consists of “control intents”: Prevention; Monitoring; and Contingency on one axis and control means on another: consisting of equipment/design or layout, procedures and competency. This process is also known as the “nine box model”. The team considers and records controls for each box.

Figure 12: Control Options Matrix

		INTENTS		
		Prevention	Monitoring	Contingency
MEANS	Equipment	PE	ME	CE
	Procedure	PP	MP	CP
	Competence	PC	MC	CC

A word of caution. This model does not replace the need to use the hierarchy of control or the duty to eliminate risks as required by health and safety legislation.

6.4.3 Assessing risk treatment options

Once all of the controls associated with a particular hazard have been identified the team should then decide which are viable and the most appropriate. It is vital that all reasons for selecting or rejecting a control are documented fully and are retained for future reference.

Selecting the most appropriate option(s) should involve a multi discipline group including persons who undertake the task where the risk is involved and technical specialists who are able to apply their skills and knowledge to the issue.

When making such an assessment various methods can be used. However, you must always ensure that you have considered the risk management context (including legal requirements). Some controls (or requirements such as noise levels or particulate concentrations) may be mandated by law and therefore are not negotiable.

Decisions made should take account of the need to consider carefully high consequence low probability risks that may warrant risk treatment actions that would not be justifiable solely on economic grounds. In some cases legal and social responsibilities may override any financial implications the control may have.

Organisations should also need to consider a time table for implementation. For example is there a long lead time to change a process, engineer a solution or modify a machine. A risk treatment plan should clearly identify the priority order in which individual risk treatments should be implemented. For example it may be possible to develop a temporary guard, develop procedures, conduct a tool box talk or training whilst other risk treatments are being undertaken.

6.4.4 Evaluating risk treatments

Risk treatment may itself introduce new risks that need to be identified, assessed, treated and monitored. You may need to ask a few questions such as:

- How effective are the actual controls that have been identified and put in place?
- Have you documented these?
- Do they treat the risk in accordance with legislative requirements?
- Do they reduce the risk to as low as is reasonably practicable as required by some legislation?
- Is the risk level still too high?
- Do they require a high level of monitoring and review?

If, after treatment, there is a residual risk, a decision should be taken about whether to retain this risk or repeat the risk treatment process.

6.4.5 Preparing and Implementing Risk Treatment Plans

The purpose of treatment plans is to document how the chosen options will be implemented. The treatment plans should include:

- Proposed actions - specifically what is required to be done. This should be a comprehensive statement of the actions or series of actions that will be undertaken to treat the risk;
- Resource requirements - especially financial and human resources required to implement the control;
- Responsibilities - a statement of who will be responsible for ensuring that the risk control actions that are completed;
- Timing - a timeframe for when the risk control actions will be finished;
- Performance measures - should be documented so that you will know that the risk control has been effective; and
- Reporting and monitoring requirements - how will you monitor and report on the progress of implementing the risk controls.

Treatment plans should be integrated with the management and budgetary processes of the organisation to ensure that controls that have been identified can be implemented. This is particularly true if the proposed control is of a capital expenditure nature, is complex or extensive requires consultation prior to implementation.



6.4.6 Communicate and Implement

Effective risk management treatments rely on those involved in doing a task and who would be affected by the control or treatment measures understand what the plan is, and what it is designed to achieve. The development of a communications strategy should be an integral part of any risk treatment.

Most communication strategies will use a variety of measures and this may mean that you will need to communicate in many forms. The methods of communication should be appropriate to the audience. They can include:

- Tool box talks;
- OHS committee meetings;
- Management meetings;
- E-mail;
- Posters;
- Mail outs;
- Brochures;
- Booklets;
- Stickers; and
- Training.



6.5 Monitor and Review

Ongoing review of risk management processes and controls is essential to ensure that the management plan remains relevant. Factors that may affect the likelihood and consequences of an outcome may change over time, as may the factors that affect the suitability or cost of the treatment options. It is therefore necessary to monitor risks and their controls at regular intervals.

Actual progress against risk treatment plans provide an important performance measure and should be incorporated into the organisation's performance management, measurement and reporting system. A formal process for monitoring risks and risk controls will ensure that risks are actually reviewed. "What gets measured gets done"

Monitoring and review also involves learning lessons from the risk management process, by reviewing events, the treatment plans and their outcomes. These lessons must be communicated and transferred back into the workplace.

There are many ways to ensure that risks are regularly reviewed:

- You can set a formal risk review committee with terms of reference and allocate roles and responsibilities;
- Your annual health and safety plan may identify what risks and their controls are reviewed;
- Senior managers may be required to audit the implementation of a key risk on an annual basis as part of the performance plan; and
- The health and safety committee may regularly review risks as a standard agenda item.

By involving employees and managers in the review process you will gain wider ownership and acceptance of risk management in health and safety in the workplace.

6.6 *Managing Change*

Mining is a dynamic and fast moving industry and the management of change is an integral part of mining activities. However many changes can introduce new hazards into the workplace if not managed correctly or can even invalidate previous risk assessments and control strategies. Changes must be managed to ensure that safety risks arising from such changes remain at acceptable levels.

Modifications and changes must be managed to ensure that safety risks arising from such changes remain at acceptable levels. Modifications may be triggered by, or required because of changes to:

- Mining methods;
- Technology;
- Licence conditions;
- The structure of the organisation;
- Expectations and requirements of stakeholders;
- Legislation or standards, or as a result of;
- Risk assessments or job safety analysis;
- Accident investigations;
- The findings of an audit;
- A senior management review of operations or the health and safety management system;
- Safety alerts or safety suggestions; or
- Updating of manufacturers advice for plant and equipment.

A mine should develop procedures and processes to monitor modifications and changes occurring in mine process and to respond appropriately to those changes. Procedures and processes should also be developed to review all modifications and changes as they are implemented to ensure that new hazards are not introduced into the workplace.

Changed management procedures and processes should not be stand alone procedures. They should be integrated into other mine management processes such as

- Planning of mining and work methods;
- Purchasing of new mining equipment;
- Training of staff (eg to operate new equipment or technology); and
- Budgeting

A mine should also undertake an internal and external environmental scan once a year to identify what has changed in the past 12 months and what may change in the next 12 months.

The scan should include legislation, codes, standards and best practice as well as work methods, equipment and changes to the mining industry. This will assist the mine to review its processes and procedures and target those risks where the situation has changed significantly and where action may be required. Employees should be consulted during the scan and again during any proposed change.

7. Risk Assessment Tools

7.1 Examples of Qualitative Assessment

Many mining companies have developed their own forms of qualitative (or preliminary) risk assessment, and there are recognised published methods. The most common approach is a “Risk Matrix”, which assesses individual incidents in terms of categories (e.g. “low”, “medium”, “high”) of their expected likelihood and severity. An example of the Risk Matrix approach is provided in the Australian Standard AS 4360 (Risk Management). Risk Matrices may need to be tailored to meet the requirements of local legislation. Risk Nomograms provide a similar but alternative approach.

Such methods can provide a relatively rapid understanding of the risk profile of the mine, and can be based on judgement alone or can be refined using more detailed information. However, it is not easy to incorporate the effects of risk reduction measures within the Risk Matrix, and neither method is easy to use to assess cumulative hazards, in particular at mines where a large number of mining hazards exist. More detailed methods may be needed to assess such issues as required by local legislation.

When using risk matrices or nomograms it is important to define individual incidents or scenarios on a consistent basis, so that compatible events are assessed. For example a risk matrix could be used to evaluate specific outcomes of incidents. (e.g. five fatalities from a major ground fall) or as specific cause of an incident (failure of bolts). The likelihood and severity would be defined very differently depending on which definition of the incident used. Hence it is vital that how incidents will be defined is discussed and agreed, and an assessment uses the same approach for all incidents. A balance must be struck between defining events in sufficient details and defining too many events to manage in the assessment.

Three examples of qualitative risk assessment are given below:

- Figure 13: Risk Matrix
- Figure 14: Risk Nomogram
- Figure 15
- SPEAR Matrix (Safety, Production, Environment, Assets and Reputation) where health and safety issues are considered along with other risks.

Word of Caution – the following models tend to have a high focus on safety or acute issues. Chronic or long term issues such as hearing loss, soft tissue damage, lung damage, skin diseases and other health issues that may occur over the longer term also need to be identified, assessed and controlled.

Note: A range of additional tools and lists to assist with risk management are contained within the appendices

Figure 13: Risk Matrix

Likelihood						
Could occur in mine lifetime 1 / 10 years	5	5	10	15	20	25
Has occurred in our company 1 / 100 years	4	4	8	12	16	20
Has occurred in the industry sector 1 / 1000 years	3	3	6	9	12	15
Has occurred in industry worldwide 1 / 10,000 years	2	2	4	6	8	10
Not known to have occurred <1 / 10,000 years	1	1	2	3	4	5
Risk Index in squares = likelihood x severity		1	2	3	4	5
		No injuries	First Aid treatment	Medical treatment required	Extensive injuries	Death
		Severity / Consequence				

	Requires priority action
	Must be reduced SFAP
	Acceptable if SFAP

Figure 14: Risk Nomogram

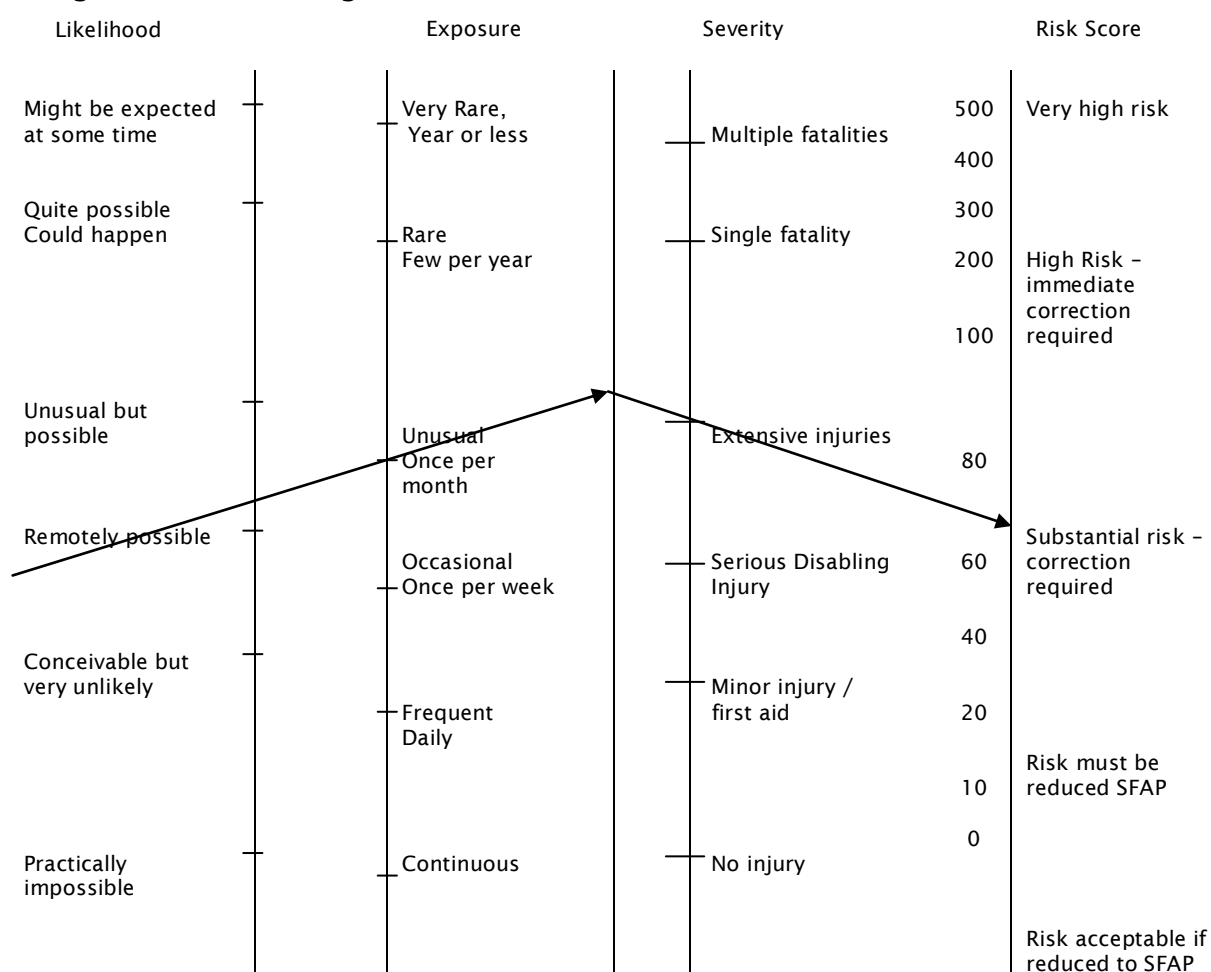


Figure 15: SPEAR Matrix

Severity	Safety (Harm to people)	Production (Losses)	Environment (Impacts)	Assets (Equipment)	Reputation (Public Relations)
1	Death	More than one week	Major effect – severe environmental damage	>\$500k	National public concern – national media attention
2	Extensive injuries	3 days to one week	Local effect – discharge of known toxic material	\$100k – 500k	Regional concern – considerable media interest
3	Medical treatment required	1 day to 3 days	Local environmental damage – contamination off site	\$20k – \$100k	Local public concern – local media interest
4	First Aid treatment	1 hour to 1 day	Minor effect - on-site spill or release	\$5k – \$20k	Public awareness but no concern
5	No injuries	1 hour	No impact	<\$5k	No public awareness

Likelihood	Explanation
A	Common - Could occur in mine lifetime – 1 / 10 years
B	Likely - Has occurred in our company – 1 / 100 years
C	Possibly - Has occurred in the industry sector - 1 / 1000 years
D	Unlikely - Has occurred in industry worldwide – 1 / 10,000 years
E	Practically impossible - Not known to have occurred <1 / 10,000 years

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

Risk Index in squares = likelihood x severity

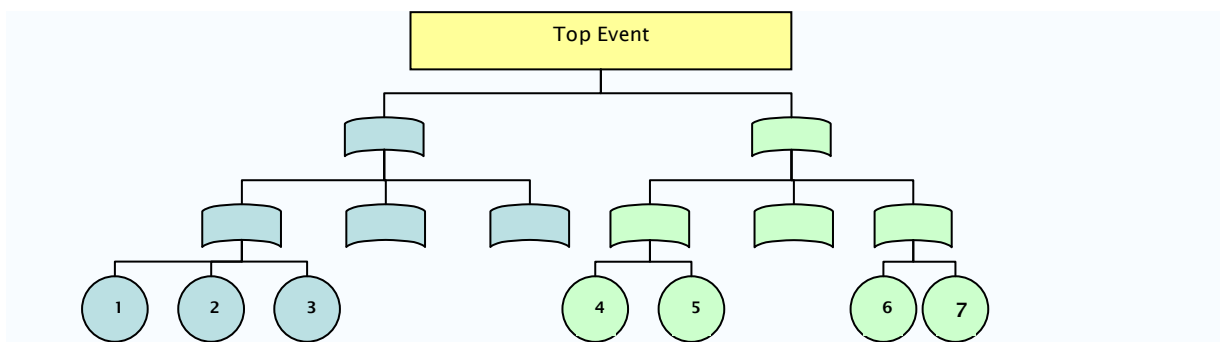
	Requires priority action
	Must be reduced So Far As is Practicable (SFAP)
	Acceptable if SFAP

8. Examples of Detailed Risk Assessment Tools

8.1 Fault Tree Analysis

Fault tree analysis is a way of finding problems and of making plans to cope with failures. Fault tree analysis must be based on a thorough process of logic and facts. It is often used when there are multiple potential causes of an incident. An undesired event or effect is taken as the root ('top event') of a tree of logic. Then, each situation that could cause that effect is added to the tree as a series of logic expressions. The Tree is usually written out using conventional logic gate symbols. The route through a tree between an event and an initiator in the tree is called a Cutset. The shortest credible way through the tree from Fault to initiating Event is called a Minimal Cutset.

Figure 16: Simplified Fault Tree

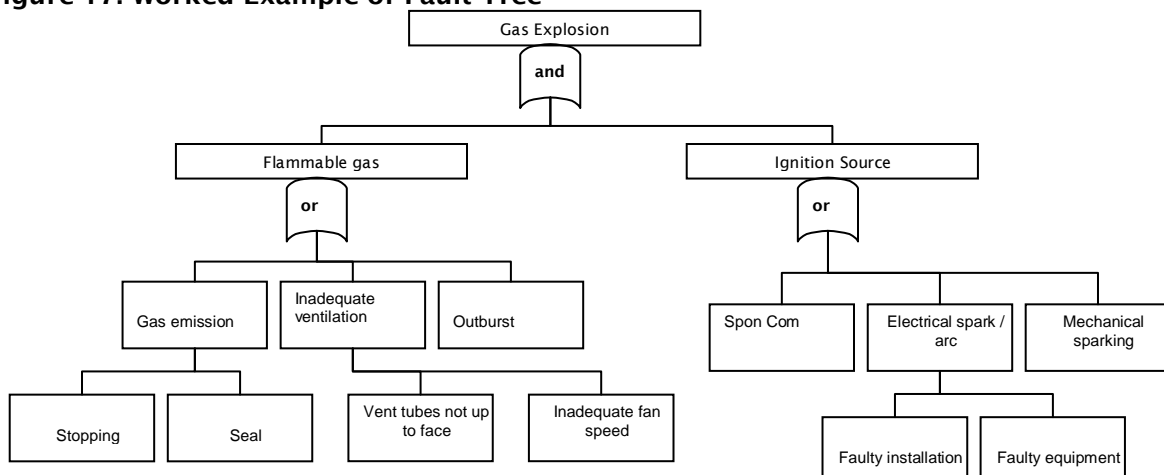


In this way the use of fault tree analysis provides a structured approach to developing a good understanding of how causes of an event and controls to prevent the event occurring are linked. In the example below the potential causes of an underground gas explosion are analysed. For a gas explosion to occur it requires two circumstances (essential factors) or events to occur at the same time:

- Flammable gas must be present in a concentration that is explosive; and
- There must be an ignition source

Underneath the two essential factors are the possible root causes (or contributing factors).

Figure 17: Worked Example of Fault Tree

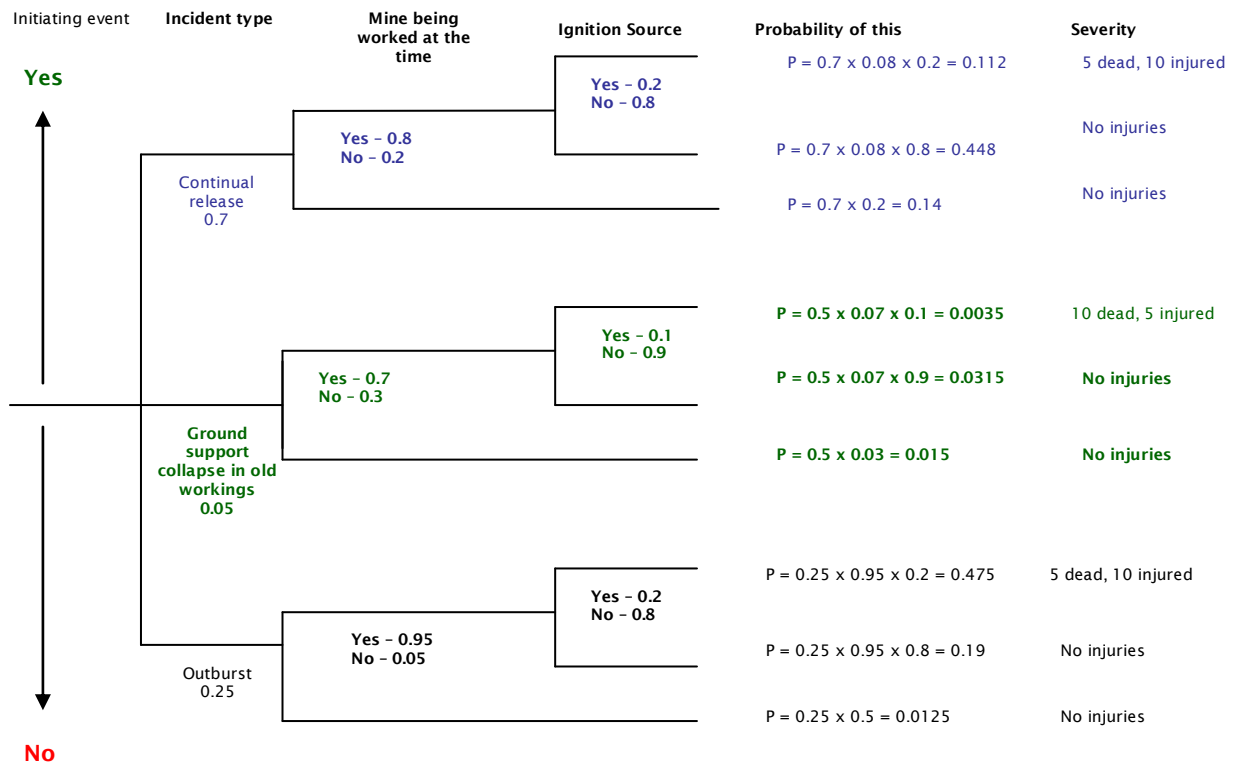


8.2 Event Trees

Event tree analysis is also a useful way of finding problems and of making plans to cope with failures. An Event Tree starts from an undesired initiator (loss of critical supply, component failure etc) and follows possible further system events through to a series of final consequences. As each new event is considered, a new node on the tree is added with a split of probabilities of taking either branch. The probabilities of a range of 'top events' arising from the initial event can then be seen.

One of the main difficulties of this method is making the estimates of probability of each of the alternatives. The justifications for each probability would need to be recorded by the group for future reference particularly if the probabilities were estimates and not based on known failure rates.

Figure 18: Event Tree



Check Total of probabilities = 1.00

If the likelihood of a gas explosion in a mine is estimated to be 0.05% per year, then the frequency of accidents in which people would be killed would be:

0.05 per year \times (0.057+0.0035+0.104) = .008225 per year.

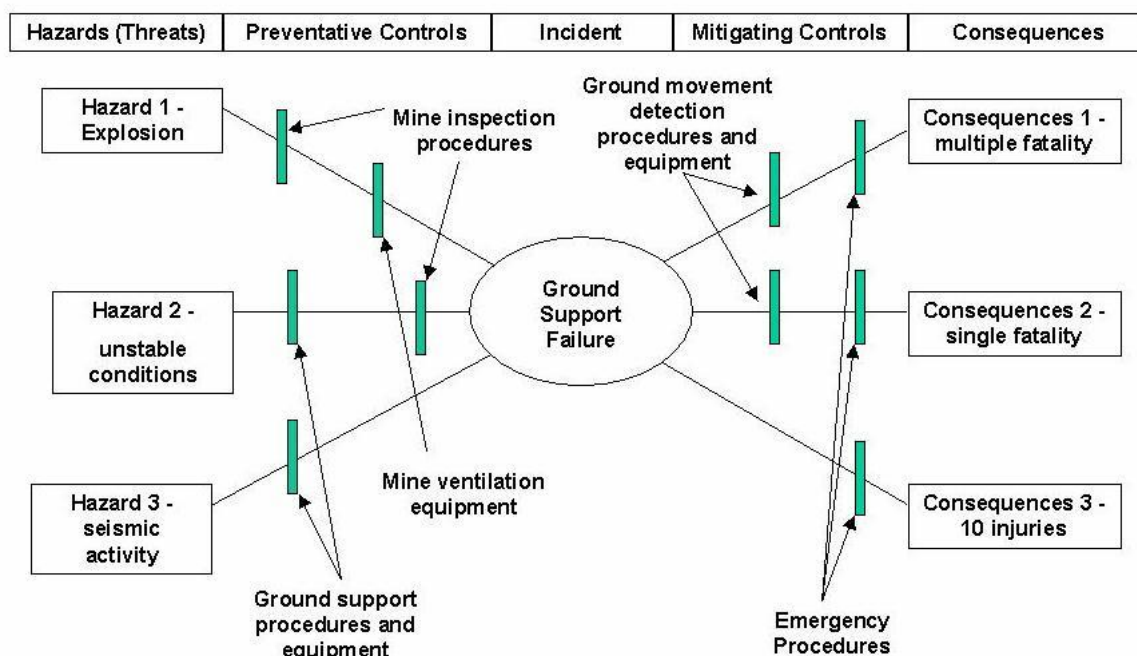
8.3 Bow Tie Diagram

A mine will typically have a range of mining hazards that need to be identified and assessed. The highest risk to health and safety and the overall profile of risks from all of these mining hazards needs to be determined. This is so that we can understand which are the most important overall contributors to the risk profile and determine whether overall risks are adequately controlled. In cases where a large number of different hazards and potential incidents exist, the cumulated risk may be significant even if the risk arising from each is low.

These issues can be illustrated in the form of a bow tie diagram. The bow tie diagram is similar to a combined fault and event tree that shows how a range of causes, controls and outcomes can be linked together and associated with each major incident scenario. A bow tie can be envisaged for every major mining hazard scenario identified for the mine.

Cumulative consideration of the hazards can be seen as the overall evaluation of interactions between different parts of a single bow tie or consideration of a range of bow ties together. Hence cumulative consideration of hazards enables the group to assess the overall picture of the facility risks, and to understand how different causes and events can combine to lead to an incident. It also enables the key causes and controls for the risk to be identified and evaluated in more detail if required.

Figure 19: Bow Tie Diagram



8.4 *Critical Success Factors*

To ensure risks are managed effectively the risk assessment must identify all mining hazards and activities, procedures, plant, processes, substances, situations or other circumstances that could pose a risk to health and safety in relation to the identified mining hazards. The risk assessment should:

- Be based on all relevant information and experience and use appropriate practicable techniques for hazard identification;
- Be robust, appropriate and timely in relation to the facility. The detail and effort should correspond with the level of complexity of the mine, and the mining methods;
- Use tools and people appropriate to the nature of the plant and the operations being analysed;
- Include consultation with Health and safety representatives, employees or representatives of the employees regarding the risk assessment, and the roles of employees within this process; and
- Employees must be informed of the results of the risk assessment process.

The risk assessment team should use realistic and lateral thinking to develop a comprehensive range of hazards and events including appropriate worst case scenarios.

The process used should be systematic and structured. It must be fully and transparently documented (including methods, criteria, assumptions and results) such that other parties may review these factors.

The definition of each mining hazard should be clear and detailed enough to properly distinguish each. A vague or generic hazard description will result in a vague or generic safety assessment.

The assessed risks and subsequent controls should become part of the overall health and safety management system.

9. Assessing the Effectiveness of Controls

9.1 Critical Success Factors

At most mines formal controls are likely to be in place already for many risk exposures. However these controls may not have had their effectiveness assessed. If controls have deteriorated over time or are not fully implemented this may have catastrophic consequences.

9.1.1 The Risk Control Practices Matrix

A risk control matrix can be used to confirm that a control is in place and to validate the effectiveness or otherwise, of each relevant identified control. To assess control practices in place, the following questions can be applied:

- Does the control address the risk effectively?
- Is the control officially documented and communicated?
- Is the control in operation and applied consistently?

The matrix set out below should be used to score the control related responses to the above questions. Scores are to be added to give a total.

Table 1: Risk Control Matrix

		Does the control address the risk effectively	Is the control officially documented and communicated	Is the control in operation and applied consistently	
Answer / response	Yes =	1	1	1	
	Partially =	3	2	2	
	No =	6	3	3	Total control rating
	Add scores				

For example, a control that addresses the risk, is officially documented, and is in operation would score 3 (1 +1 +1); a perfect score. Such an evaluation process enables the organisation to assess how well the controls for risks are being implemented and it also provides a warning to management when controls are not properly implemented or understood by the workforce.

To help employees to describe and attribute a control rating to the scores derived from the control practices matrix, the following indicative ratings below can also be used:

Table 2: Risk Control Descriptions

Score	Rating	Description
3	Excellent	Control addresses risk, is officially documented and in operation consistently across the organisation
4	Good	Control addresses risk but documentation and / or operation of control could be improved across the organisation
5 – 6	Fair	Control addresses risk at least partially, but documentation and or operation of control could be improved
7 – 12	Poor	At best, control addresses risk, but is not documented or in operation; at worst, control does not address risk and is neither documented nor in operation

This evaluation process can be used to identify priorities for action and gaps in implementation. It should be conducted by a multi disciplinary group preferably the one that undertook the original risk assessment.

If a simple risk matrix has been used to assess the risk it is then possible to determine a single risk rating taking in account consequences, likelihood and the effectiveness of the control. Then results of the risk assessment can then be entered into a single risk rating table. Risks can then be re-ranked to identify if there are any high risks with ineffective controls for further action.

Table 3: Combined Risk Rating Table

Single Risk Rating Table		
Risk: Occupational Hygiene		
Commentary		Ratings
Risk Description	Failure to assess workplace dust / particle levels and take action to minimise the risk to workers from disease	
Likelihood	Staff operate in workplace environments subject to airborne particulate hazards	3
Consequences	Possible multiple deaths	5
Combined Risk Score (Likelihood + Consequences)		8
Internal control procedures Procedures fully address – health policies, ventilation and PPE standards exist All procedures documented and approved Monitoring of dust and particulate levels conducted regularly and results reported	Addresses risk	1
	Documentation	1
	In Operation	1
Control Rating Total		3
Overall Risk Ranking (Combined risk score + Control Rating Total)		11

10. Risk Management Data Base

Before you start

This risk management data base has been created in Microsoft Access. It is designed as a stand alone data base. It can be put onto a network but it is not designed to be simultaneously updated by more than one user at a time. Access has an upgrade path. So, if performance starts to suffer from an ever increasing number of users or records, you can upsize to SQL Server and use Access as a front-end.

You can modify the data base, reports and lists as required to suit your operations. However please note that no additional development, support or warranties (implied or explicit) are offered with the data base.

Getting Started

Create a new directory and copy across the data base file. As a precaution save the file once and again using another name. This means you can practice with one data base and save the other for later use.

You can create a short cut for the data base by right clicking on the file in explorer. You can then place the short cut on your desk top.

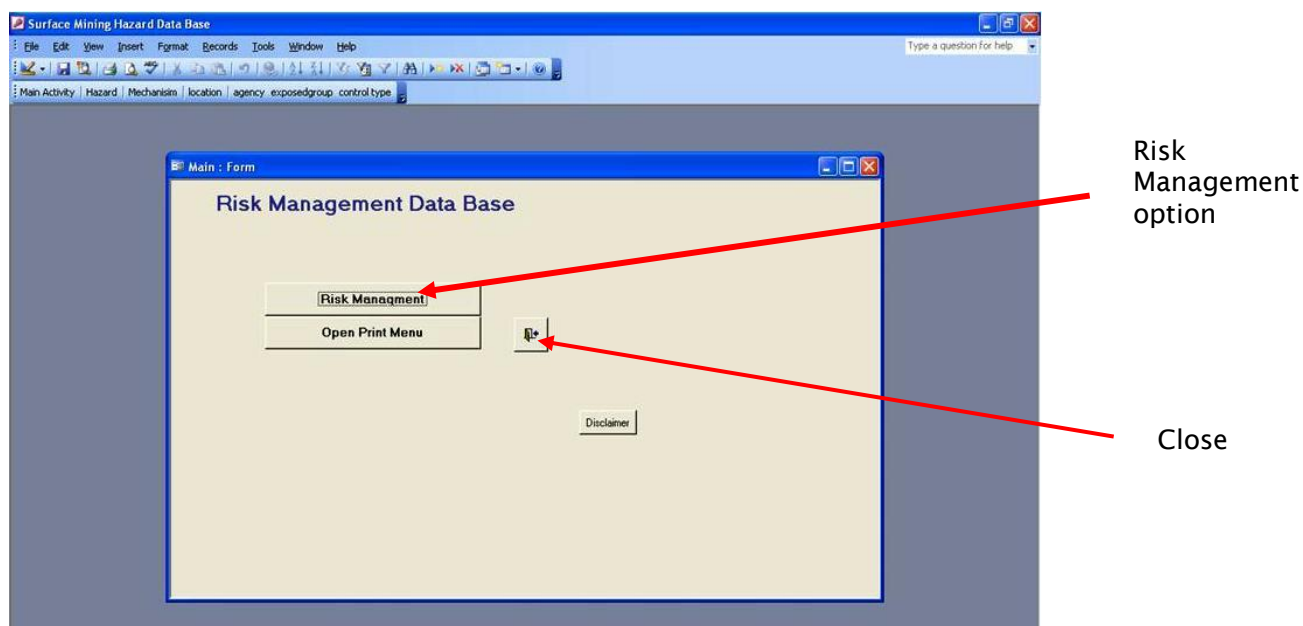
Important Note

The data base has been pre-scanned for viruses however, as a precaution before you use the data base for the first time you should re-scan it for any viruses. Once you have checked that the files are virus free you are ready to copy the files to your computer and use the data base.

Getting Started

Double click on the file or short cut and you will see the screen below.

There are two menu options: Risk Management and the Print Menu. If you are using the data base for the first time select the risk management option to explore the data base.



Note: If you want to get access to the underlying tables and forms, you have to hold in the control key on your keyboard while opening the file.

Risk Management Data Entry Screen

This is the main data entry screen. This is what you will see when you open the risk management option. The screen has several features including automatic risk score calculations, drop down selection menus, pop up hazard and risk lists as well as control options.

The screenshot shows the 'Surface Mining Hazard Data Base' application window. The 'Risk Assessment' form is displayed with the following fields and annotations:

- Menu Bar:** File, Edit, View, Insert, Format, Records, Tools, Window, Help. An arrow points to the 'Records' menu with the label: "Pop up hazard and risk list tool buttons".
- Record number:** 1
- Main Activity:** Noise. An arrow points to the 'EDIT' button next to it with the label: "Edit button".
- Hazard:** Machinery
- Mechanism:** Mobile Plant. An arrow points to the dropdown arrow next to it with the label: "Drop down selection menu".
- Brief Description:** Driver unable to see edge of haul road and vehicle goes over the edge of ramp.
- Consequences:** 2
- Exposure:** 2
- Probability:** 2
- Risk Level:** 20. An arrow points to the result with the label: "Automatic risk score calculator".
- Key Contact:** Contact: Hayden Carter. A button 'Modify / Add contact' is next to it.
- Risk Control Plan:** A table with columns: Control Type, Control Details, Person, Due Date, Completed.

Control Type	Control Details	Person	Due Date	Completed
Personal Protective E	Bunding and cats eyes			
Training	Haul road drivers trained to recognise risks of poor visibility			

 An arrow points to the 'Training' dropdown with the label: "Control options".
- Buttons:** Refresh, Print, and a save icon.
- Footer:** Record: 14 of 14

Your record is automatically saved by Access when you either scroll to a new record or close the form.

If you need to alter a record that has been saved, the record can be changed by clicking the "edit button" and making the changes.

Entering Risk Data

Each data field can now be entered. This can be done in real time as the risk assessment is being undertaken or later if accurate records are being taken. If you are doing the risk assessment in real time always back up your data to a second source regularly as computer failure or a crash could mean that you lose all of your work.

Begin with the risk descriptions:

- Main Activity;
- Hazard;
- Mechanism; and
- Brief description

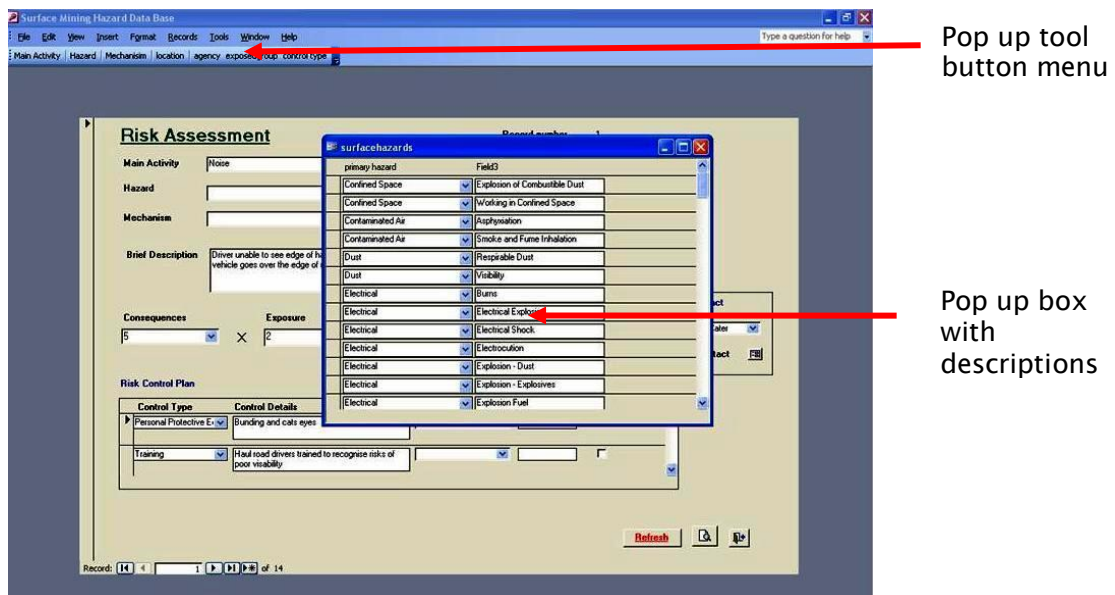
The Main Activity, Hazard and Mechanism descriptions can be entered from drop down menus. By clicking on the pop tool button (within the data base – see previous page) for Main Activities, Hazards and Mechanisms you will be able to see the full lists and how the existing relationships are structured. The data base is designed to link Main Activities, Hazards and Mechanisms so that only relevant hazards and mechanisms appear when a main activity is selected.

Additional Main Activities, Hazards and Mechanisms can be added by clicking the categories pop up menus at the top of the risk management screen. First, check if the main activity that you wish to select is in the data base. If it is, select the hazard from the drop down list. This will automatically populate the hazard drop down box.

1. If the main hazard you wish to enter is not on the list use the pop up menu to add it to the data base.
2. If the mechanism you wish to use is in the data base select it from the drop down box.
3. If the hazard you wish to enter is not on the mechanism list use the pop up menu to add it to the data base.

You should do this in sequence to ensure that you do not add unnecessary categories or descriptions. The brief description box is a free text area for you to add detail to customise the explanation of the risk.

Once you have made additions click the refresh button.



Definitions

Once you have the risk descriptions recorded, you are ready to assess the risk. The data base uses the $\text{Consequences} \times \text{Exposure} \times \text{Probability} = \text{Risk Level}$ model to assess the risk. Note you can also use the data base in a $\text{Consequences} \times \text{Likelihood}$ model (just ignore the last category) or a 5×5 model (again just ignore the last category).

Risk Assessment

Record number: 1

Main Activity: EDIT

Hazard:

Mechanism:

Brief Description:

Location:

Agency:

Exposed group:

Consequences: =

Exposure:

Probability:

Risk Level:

Key Contact:

Risk Control Plan

Control Type	Control Details	Person	Due Date	Completed
<input type="text" value="Personal Protective E"/>	<input type="text" value="Banding and cat eyes"/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="checkbox"/>
<input type="text" value="Training"/>	<input type="text" value="Haul road drivers trained to recognise risks of poor visibility"/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="checkbox"/>

Record: 14 of 14

Enter risk description data here

Drop down boxes and automatic risk score calculator

Definitions

The definitions that apply in the data base to the assessment of risks are:

Consequences - The outcome or impact of an event. There can be more than one consequence from one event and the consequences can range from positive to negative. Consequences can be expressed qualitatively or quantitatively.

Exposure - Frequency and Duration of the exposure to persons to the chosen hazard.

Probability - Likelihood or chance that the chosen sequence of events and consequence will occur

Source: AS / NZS 4804:2001, Occupational Health and Safety Management Systems – General Guidance on Principles, Systems and Supporting Techniques, Standards Australia, Homebush.

Consequence, Exposure and Probability Tables

Consequence, Exposure and Probability tables are used to provide definitions for rating scales so there is a common understanding of their meaning. The tables below are simple descriptive tables which can be used in conjunction with the risk management data base to determine relative risk levels.

Consequence Scale		
1	No injury	
2	Minor injury	Lost time injury / minor medical treatment
3	Seriously disabling injury	Temporary loss of body function (eg broken bone)
4	Extensive injuries	Permanent loss of body function (hearing loss / amputation)
5	Single fatality	
6	Multiple fatality	

Exposure Scale		
1	Very rare	Less than one exposure every ten years
2	Rare	Exposure may occur once every few years
3	Unusual	Persons may be exposed several times per year
4	Occasional	Persons may be exposed several times a month
5	Frequent	Persons are exposed on a weekly basis
6	Continuous	Persons are exposed to the hazard all of the time

Probability Scale		
1	Rare	Will not occur in most circumstances, almost impossible
2	Unlikely	Event has occurred somewhere in the world
3	Moderate	Event has occurred somewhere within organisation
4	Likely	Event has occurred sometime on site
5	Almost Certain	Event is more than likely to occur in next 12 months
6	Certain	Event will occur more than once a year

Adding Controls and Responsible Persons

Controls for each hazard can also be added. Select the control type from the drop down box. Control categories are:

- Procedure
- Training
- Design
- Equipment
- Personal Protective Equipment

The control details box is a free text area for you to add detail to customise the explanation of the control. You can also add:

- A responsible person (through the key contacts register);
- Due by date (which must be entered in the format dd/mmm/yy eg 01/Jan/07; and
- There is a check box to indicate if the control has been completed.

You can also add a key contract for the risk. There is also a modify / add button. To add or modify the contact details click the button and the contact details register will pop up. This is useful if for example you wish to designate someone who has particular knowledge about the risk or provides a service connected with a control.

Surface Mining Hazard Data Base

File Edit View Insert Format Records Tools Window Help

Main Activity | Hazard | Mechanism | Location | Agency | Exposed group | Control type

Risk Assessment Record number 1

Main Activity: Noise EDIT Location: Maintenance Workshop

Hazard: Machinery Agency: Mobile Equipment

Mechanism: Mobile Plant Exposed group: Production

Brief Description: Driver unable to see edge of haul road and vehicle goes over the edge of ramp.

Consequences: 2 Exposure: 2 Probability: 2 Risk Level: 20

Key Contact

Contact: Hayden Carter

Modify / Add contact

Risk Control Plan

Control Type	Control Details	Person	Due Date	Completed
Personal Protective E	Bunding and cats eyes			
Training	Haul road drivers trained to recognise risks of poor visibility			

Record: 14 of 14

Adding a Key contact

Control Box

To View a Report

The data base has a number of pre loaded reports. You can report by risk or hazard. First, you must select the type of report you wish to review. The print report by hazard will list them in numeric order as they have been entered. The risk report by hazard will group them by hazard categories such as dust. Other reports can also be generated:

- Personal Hazard;
- Outstanding actions;
- Overdue; and
- Completed.

You can also select a report by person allocated in the controls. Simply select the type of report you wish to run and click. As with all access data bases existing reports can be modified and new reports can be added.

Surface Mining Hazard Data Base

File Edit View Insert Format Records Tools Window Help

Main Activity: Hazard Mechanism: location: agency: exposedgroup: control type:

Risk Assessment Record number: 1

Main Activity: Noise EDIT Location: Maintenance Workshop

Hazard: Machinery Agency: Mobile Equipment

Mechanism: Mobile Plant Exposed group: Production

Brief Description: Driver unable to see edge of haul road and vehicle goes over the edge of ramp.

Consequences: 8 Exposure: 2 Probability: 2 Risk Level: 20

Key Contact: Contact: Hayden Carter Modify / Add contact

Risk Control Plan

Control Type	Control Details	Person	Due Date	Completed
Personal Protective E...	Bunding and cats eyes			
Training	Haul road drivers trained to recognise risks of poor visibility			

Record: 14 of 14

Refresh Preview Print

Print Menu Button

To print a report click the preview button and then click the print button.

Exporting Data

You can export any report to Word or Excel from the view report screen and edit the report through the office links button. Click the Word symbol and the report is automatically exported to word.

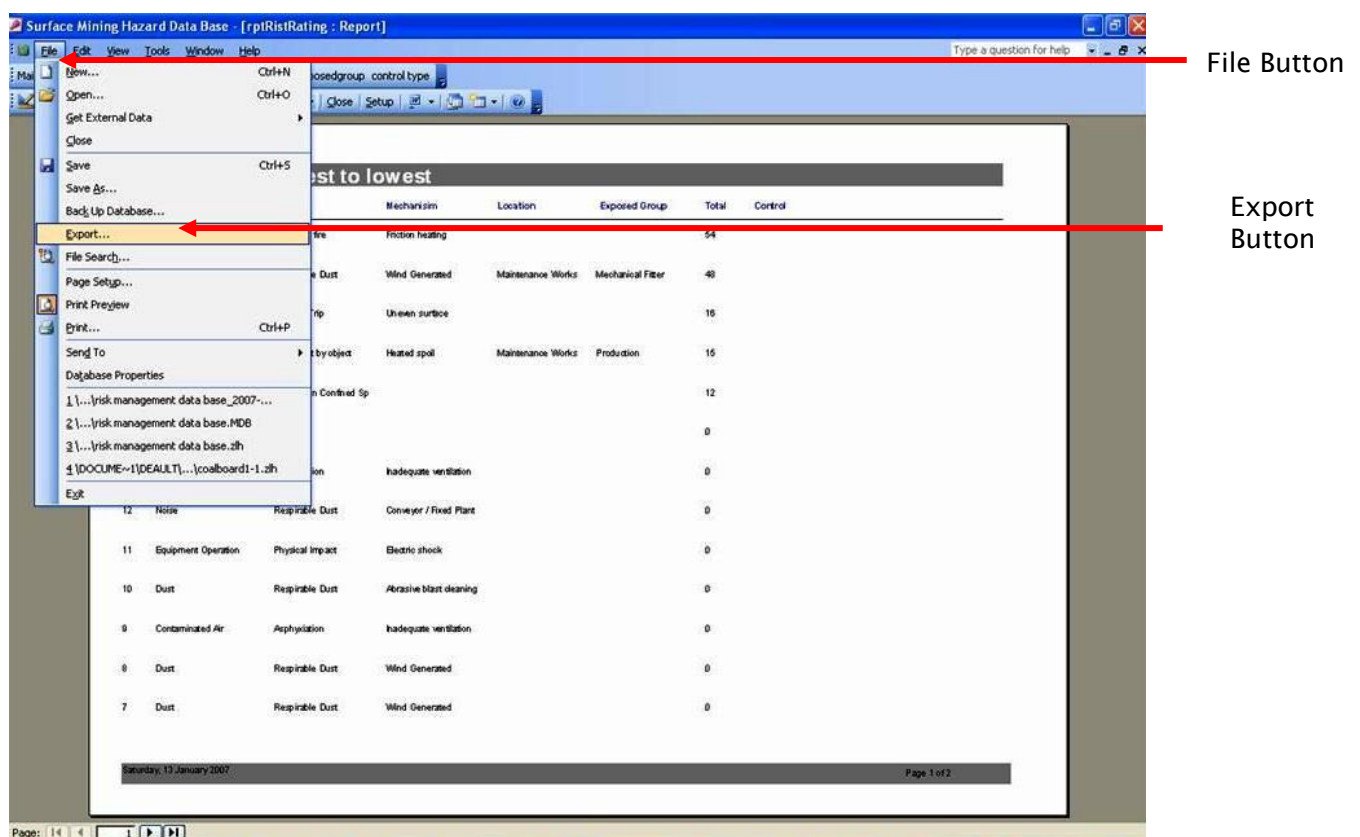
The screenshot shows a web application window titled "Surface Mining Hazard Data Base - [rptHazard - Report]". The window has a menu bar (File, Edit, View, Tools, Window, Help) and a toolbar with icons for Print, Export to Word, and Export to Excel. A red arrow points from the "Print Menu Button" label to the Print icon. Another red arrow points from the "Export to Word or Excel" label to the Export to Word icon. The main content area displays a "Risk Report" table with the following data:

ID	Main Activity	Hazard	Mechanism	Location	Exposure	Total	Control
2	Dust	Respirable Dust	Wind Generated	Maintenance Works	Mechanical Filter	40	
7	Dust	Respirable Dust	Wind Generated			0	
8	Dust	Respirable Dust	Wind Generated			0	
10	Dust	Respirable Dust	Abrasive blast cleaning			0	
14	Dust					0	

At the bottom of the window, there is a status bar showing "Saturday 9 January 2007" and "Page 1 of 1".

Alternatively, data or reports can be exported from a report to either Excel or Rich Text Format for use with word processing documents. Once you have generated the report that you wish to export

1. Click on the file button at the top of the screen;
2. Select Export;
3. Select the type of file you wish to save Excel or Rich Text Format;
4. Name the file (give the file a unique name); and
5. Save the file in a location you will remember.



Reviewing Exported Data

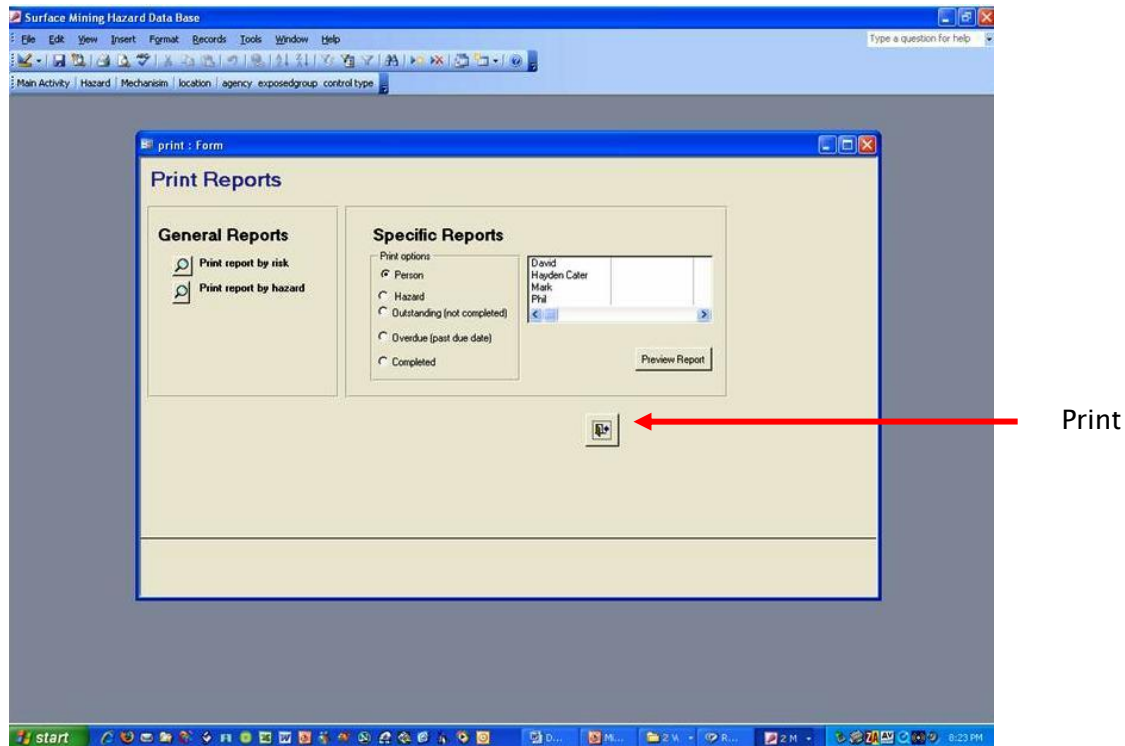
Data or reports that have been exported from a report to either Excel or Rich Text Format can be used with word processing documents.

You can use the data to develop graphs and reports such as the one below that has been generated in Excel.

ID	Main Activity	Hazard	Mechanism	Location	Exposed Group	Total	Control
3	Fixed Plant	Conveyor fire	Friction heating			54	
2	Dust	Respirable Dust	Wind Generated	Maintenance Work	Mechanical Filter	48	
4	Slip / Trip	Slip and Trip	Uneven surface			16	
1	Ground Control	Person hit by object	Heated spoil	Maintenance Work	Production	15	
5	Confined Space	Working in Confined Space				12	
14	Dust					0	
13	Contaminated Air	Asphyxiation	Inadequate ventilation			0	
12	Noise	Respirable Dust	Conveyor / Fixed Plant			0	
11	Equipment Operation	Physical Impact	Electric shock			0	
10	Dust	Respirable Dust	Abrasive blast cleaning			0	
9	Contaminated Air	Asphyxiation	Inadequate ventilation			0	
8	Dust	Respirable Dust	Wind Generated			0	
7	Dust	Respirable Dust	Wind Generated			0	
6	Explosions	Ignition of Dust				0	

Return / Exit the program

You can exit the program at any time by clicking the return button. The return button will take you to the previous screen. If you are at the main page it will exit the program.



11. On-going Management of Risk

11.1 Risk Register

The risk assessment process and register is a key document in the effective management of health and safety risks. All Mine sites should develop and maintain a consolidated health and safety risk register. Risk register may be held in electronic or hard copy.

At a minimum the risk register should contain:

- A listing of all hazards identified;
- Clear descriptions of the risks being assessed;
- Risk scores;
- Current controls;
- Actions to be undertaken;
- People responsible for those actions; and
- A due by date.

The risk register should be maintained and updated by a designated officer. It should be made available to all persons on site.

Senior Management should formally review the risk register:

- On an annual basis; or
- Where major operational changes occur or are planned to occur at the mine site; or
- Where changes to operational circumstances occur or are planned to occur at the mine site

The controls from the risk register should then be incorporated into a mines health and health and safety management system. The controls identified should be subject to audit, inspection, monitoring and review.

11.2 Management Systems

What is a Health and Safety Management System?

A Health and Safety Management System (HSMS) comprises all policies, objectives, roles, responsibilities, accountabilities, codes, standards, communications, processes, procedures, tools, data and documents for managing safe operation of the mine specifically with regard to mining hazards.

A HSMS is not just documentation but is the actual implementation of processes, procedures and practices at the mine. The HSMS therefore should both include and reflect the safety culture at the workplace. A mine should have a HSMS that incorporates:

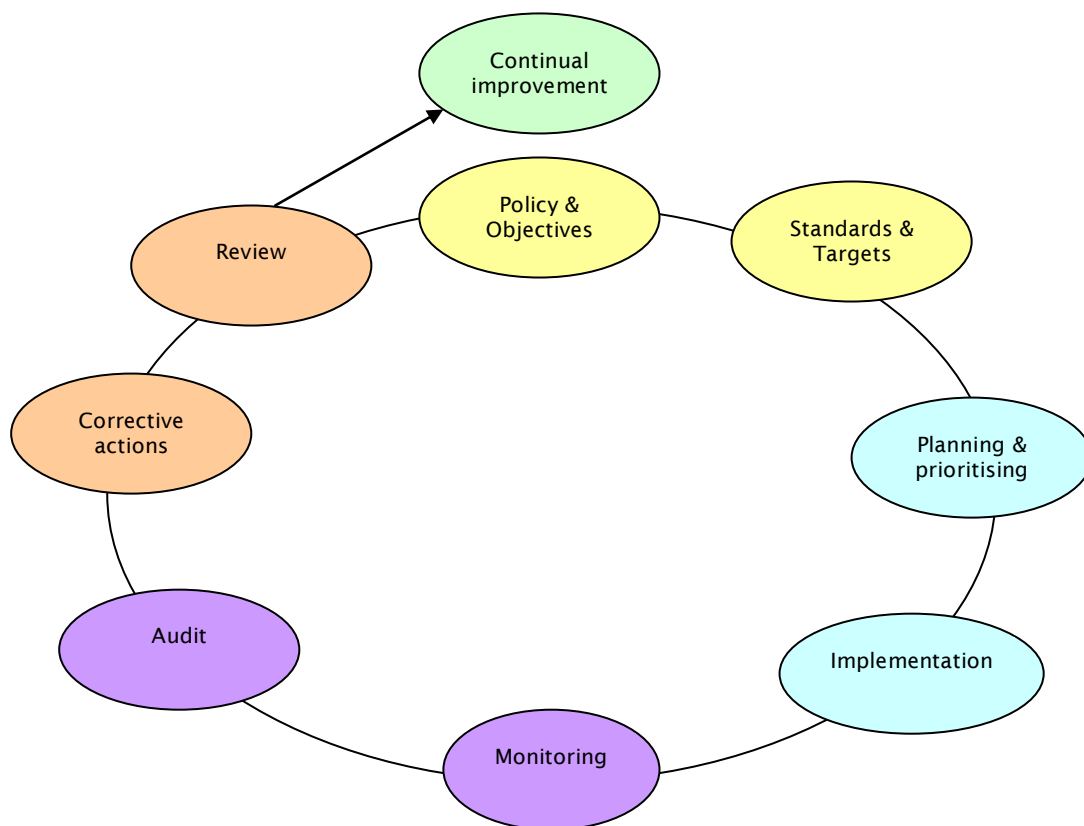
- The organisation's health and safety policy;
- The systems, procedures and other control measures by which risks to health and safety associated with mining hazards are to be controlled; and
- The performance standards for measuring the effectiveness of the HSMS.

A HSMS generally consists of two major components:

- A set of generic management system elements that provide a systematic process for planning, implementing, monitoring, taking corrective action, and reviewing performance in relation to the hazards and potential major incidents, and their corresponding control measures; and
- A set of specific health and safety management system elements, which address the nature of the mine, its mining methods, hazards, potential major incidents and associated risk, and which are therefore the control measures in relation to the potential major incidents.

Health and Safety Management Systems need to reflect the mining hazards that are present and support the actual practices on the mine.

Figure 20: Health and Safety Management System Elements



General Health and Safety Management System Requirements:

- The organisation's health and safety policy;
- Description of the mine, mining methods and mining hazards;
- Overview of the health and safety management system and comprehensive description of the structure of the health and safety management system providing detail of how it is integrated into normal operations;
- Procedures and processes for the development and implementation of performance measures;
- Procedures and processes to identify and assess hazards and control including a hazard register with assessment and controls listed;

- Generic Management Systems and procedures for:
 - Planning and resources;
 - Responsibilities and accountabilities;
 - Training and competencies;
 - Communication and consultation;
 - Hazard identification and risk assessment;
 - Risk control;
 - Incident reporting;
 - Incident Investigation;
 - Document and data control including availability of documentation and records; and
 - Audit and Review.
- Procedures and processes for the monitoring of the health and safety management system, its performance standards and controls;
- Procedures and processes for the audit of the health and safety management system, its performance standards and controls;
- Procedures and processes for the review and revision of the health and safety management system, its performance standards and controls; and
- Procedures and processes for corrective actions to continually improve the health and safety management system.

What is a review?

A review is the regular but less frequent process of stepping back and asking if the entire system and the standards within it remain adequate, fit-for-purpose, and in line with current good practice. A combination of Monitoring, Audit and Review is necessary to ensure the ongoing effectiveness of the health and safety management system, and to drive continual improvement.

Requirements for a Management Review and Revision

In order to maintain continual improvement, suitability and effectiveness of the health and safety management system, and thereby its performance, the mine management should review and evaluate its health and safety management system. The senior management of a mine should review, and as necessary revise, the health and safety management system if

- A modification is to be made to the mine;
- An incident involving a mining hazard occurs; or
- At least once each three years.

Conducting a Management Review

The senior management of a mine should review the continued relevance of, and change where appropriate, policy, objectives, responsibilities and other elements of the health and safety management system, in the light of audit results, changing circumstances and the commitment to continual improvement. The review should be documented and ensure that all necessary information is collected to allow management to carry out this evaluation.

The review should take into consideration:

- Health and safety performance reports;
- Incident reports;
- Changes to regulatory requirements;
- Results from audits;
- Technical reports and risk assessments;
- The extent to which targets and objectives have been met;
- Key performance indicators;
- The continued suitability of the health and safety management system in relation to the operations of the mine; and
- Issues raised through employee consultative mechanisms such as OHS committees.

Observations, conclusions and recommendations should be documented for necessary action.

11.3 Continual Improvement

Continual improvement is achieved by regularly evaluating the performance of the health and safety management system against its policy, objectives and performance standards for the purpose of identifying opportunities for improvement. The continual improvement process should:

- identify areas of opportunity for improvement in the health and safety management system that lead to improved performance;
- determine the root cause or causes for non-conformance or deficiencies in meeting performance standards or the requirements of the health and safety management system;
- develop and implement plans of corrective and preventative actions so that performance standards are met;
- verify the effectiveness of corrective and preventative actions;
- document any changes in the health and safety management system including the mine's policy and procedures resulting from the improvement process; and
- make comparisons with the objectives and targets of the health and safety management system.

11.4 Auditing the process

What is an audit?

An audit is a systematic examination and checking of the health and safety management system against defined performance standards and criteria to ensure that the health and safety management system is understood and is being used, and that the management framework (in particular the monitoring and corrective action processes) is being implemented and that it is effective.

Both quality control and quality assurance are necessary as part of these processes; checks are required that activities occur, and that the activities are being performed to a suitable standard.

Requirements for an Audit

In order to maintain continual improvement, suitability and effectiveness of the health and safety management system, and thereby its performance, the senior management of a mine should audit and review its health and safety management system. The audit should be carried out by a competent person, in order to determine that:

- The health and safety management system conforms to planned arrangements;
- Has been properly implemented and maintained;
- Is effective in meeting the mine's policy as well as objectives and targets for the continual improvement; and
- Provide information on the results of the audits to management and employees.

The audit process and procedures

The audit process and procedures should cover the scope, frequency, methodologies, criteria and competencies, as well as the responsibilities and requirements for conducting audits and reporting results.

The audit should be conducted against the mine's health and safety management system systems, procedures and other control measures by which risks to health and safety associated with mining hazards are controlled. Particular attention should be paid to the implementation of performance standards.

The audit report

Audit results should be documented, reviewed, acted upon and made available to all persons who use the health and safety management system.

The audit report should include:

- Front Page;
- Table of Contents;
- Executive Summary;
- Introduction;
- The audit scope and objectives;
- The audit details (who conducted the audit, when, where, date, etc);
- Audit criteria;
- Audit observations (including items verified);
- Instances of non compliances / non conformances;
- Opportunity for improvement;
- Conclusions;
- Recommendations; and
- Action plan.

12. Resources

Risk Management and Related Standards

Standards Australia. 2004. AS/NZS 4360:2004: Risk Management. Homebush NSW: Standards Association of Australia.

Standards Australia. 2006. AS/NZS 4360:2006: Compliance Programs. Homebush NSW: Standards Association of Australia.

Standards Australia, 2001. AS/NZS ISO 9001:2000 Quality management systems - Requirements Homebush NSW: Standards Association of Australia.

Standards Australia, 2001. AS/NZS ISO 14001:2004 Environmental management systems - Requirements with guidance Homebush NSW: Standards Association of Australia.

Standards Australia, 2001. AS/NZS 4801:2001 Occupational health and safety management systems - Specification with guidance for use Homebush: Standards Association of Australia.

Other Resources and Websites

Standards Australia:
<http://www.standards.com.au/>

The Association of Risk and Insurance Managers of Australasia
<http://www.arima.com.au/welcome.htm>

American Risk and Insurance Association
<http://www.aria.org/>

Risk Management/Insurance Information Systems (RMIS)
<http://www.rmisweb.com/>

13. References

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Appendix 1: Key Coal Mining Risks Listing

The purpose of the table is to identify key health and safety risks that are common to most organisations in the coal mining industry. The listing of risks in the table below was developed using best practice case studies and literature review. This list is intended to assist coal mining organisations and personnel by identifying key risks. This will enable coal mining organisations and personnel to quickly assess their risk management processes and registers and ensure that these key risks (at a minimum) are included, monitored and reviewed on an ongoing basis. The risks are listed in alphabetical order.

Key Coal Mining Risks	
Risk	Additional Descriptions
Biological	
Biological	Tetanus Viral Fungal Hep A, Hep B E. coli
Electricity	
Electric Shock	A failure of electrical equipment or an electrical installation causing an electric shock to a person
Emergency Management	
Inappropriate Emergency Response	Lack of resources Lack of planning
Equipment	
Persons crushed in machinery	The entrapment of a person
Equipment safeguarding	The entrapment of a person Lack of guarding Ineffective guarding Working on moving parts with guarding removed Lack of risk assessment Persons hit by objects or substances Hot surface material Hydraulic compressed air Loss of pressure Loss of control / unplanned movement Improper isolation of equipment
Equipment structural failure	A major structural failure of equipment, if the failure causes a hazard
Explosion / Ignition	
Explosion	An unplanned ignition or explosion of a blasting agent of explosive
Gas ignition	Unplanned ignition of gas, dust, or a combination of gas and dust

Falling / Flying Material	
Falling / flying material	The ejection of fly rock such as to endanger persons or property.
Fire	
Fire	On mobile equipment On fixed plant Underground
Gas Outbursts	
Gas Outbursts	An in surge of noxious or flammable gas from old workings,
Hazardous Substances Management	
Hazardous Substances management	Poor handling practices Poor storage practices Poor transporting practices Inappropriate use Inappropriate labelling
High Wall	
High Wall	A fall, slumping, loss of strength, failure or collapse of the high wall, low wall or spoil area such as to endanger persons or property,
Inrush / Inundation	
Inrush / inundation	An inrush of water An inrush of mud
Isolation	
Isolation	Failure to identify or recognise a source of potential or stored energy Inadequate training or competence Complacency Inadequate lock out tag out systems Working on or isolating the wrong equipment
Lightning strike	
Lightning strike	Electrocution Electrical Arc
Physical Work Environment	
Physical work environment	Heat Noise Mist Vehicle exhaust Dust
Psychological	Stress
Radiation	
Radiation	Electric arcs Lasers High frequency magnetic fields
Spontaneous Combustion	
Spontaneous Combustion	Spontaneous combustion of coal or other material in an underground mine
Structural Collapse	
Structural Collapse	A failure or collapse of any structure such as to endanger persons or property.

Surface Mobile Equipment

Surface mobile equipment	Overtaking Loss of traction Overturning Reversing Unplanned movements on slopes Parking protocols Ineffective communications Poor visibility Persons hit by objects or substances Dropped loads Structural failure Loss of control / unplanned movement Operator fatigue
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Underground Ground Control

Fall of ground	Unplanned fall of roof or sides of a mine that impedes passage or disrupts mine ventilation Entrapment of a continuous miner by a fall of roof or sides such that it is unable to be recovered under its own tractive effort Entrapment of a breaker line support by a fall of roof such that it is unable to be recovered under its own tractive effort Persons hit by objects or substances A creep, progressive pillar collapse or significant deviation from predicted surface subsidence A major failure of strata control
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Underground Mobile Equipment

Underground mobile equipment	Interactions between vehicles and pedestrians Unplanned movements of vehicles down inclines and slopes Poor visibility Speed Persons hit by objects or substances Loss of control / unplanned movement Rolling and tipping of vehicles Poorly maintained road surfaces
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Vehicles	
Vehicles	<p>An unplanned movement of a vehicle, machine or any item of plant or equipment such as to endanger persons or cause serious property damage,</p> <p>Light vehicle / Heavy vehicle interactions</p> <p>Speed</p> <p>High centre of gravity</p> <p>Rolling and tipping of vehicles</p> <p>Persons hit by objects or substances</p> <p>Multiple vehicle accidents</p> <p>Driver fatigue</p> <p>Failure to wear seat belts</p> <p>Lack of protective devices</p> <p>Poorly maintained road surfaces</p>
Ventilation	
Ventilation	<p>Inadequate ventilation</p> <p>Airborne particulates</p>
Windblast That Results in Injuries	
Windblast that results in injuries	
Winding, Haulage or Conveyor	
Winding, haulage or conveyor	Persons hit by objects or substances
Working at heights	
Working at heights	<p>Persons falling from heights</p> <p>Failure to wear fall protection</p> <p>Wrong sort of harness</p> <p>Incorrect use of fall protection</p> <p>Lack of job planning and assessment</p> <p>Unstable work platforms</p>

Source: Report to The Coal Services Health and Safety Trust – Improving OHS Risk Management Strategies in Coal Mines (2007)

Appendix 2: Risk Description Examples

Mining Hazard	Description of process or hazardous circumstance	Hazardous Event Scenario
Mining Plant	Conveyor Maintenance / Repair (Conveyor XYZ)	Poor isolation practices and conveyor is inadvertently started by another operator.
		Emergency stop fails to operate.
		Conveyor starts up remotely without warning Entrapment with moving parts (Tail Drum).
		Conveyor starts up remotely without warning Entrapment with moving parts (Rollers).
	Haul Truck Fire - Cat 789 (230 T) haul truck	Caused by electrical fault.
		Caused by hydraulic hose burst.
	Haul truck hauling full load up haul road (or decline) - Cat 789 (230 T)	Caused by loss of steering.
		Caused by loss of brakes (due to electrical fault).
		Caused by loss of power
		Loss of brakes due to (mechanical fault).
		Poor visibility (weather).
		Poor visibility (poor light).
Loss of Ventilation	Ventilation underground is inadequate and creates toxic atmosphere	Due to power supply failure.
		Poor design of electrical installations
		Poor maintenance of electrical installations
		Mechanical failure.
		Structural damage caused by impact of mining equipment.
		Structural damage caused by impact of mining vehicle
		Ventilation management - ventilation structures not properly designed.
		Ventilation management - ventilation structures not properly installed.
		Ventilation management - ventilation structures not properly maintained.
		Damage created by ground collapse
Mine Fire or explosion	Inadequate storage of explosives causes explosion	Segregation and storage practices
		Magazine design
		Magazine location
		Security of magazine
		Transportation procedures and practices
	Misuse of explosives (theft)	Security of magazine
		Control of inventory
		Supervision of shot firers
		Supervision of employees and contractors
Slope stability	Bench is inadequate and collapses	Design of bench
		Construction of bench
		Maintenance of bench

Appendix 3: Example of Cumulative Mining Hazards Listing

Mining Hazard	Description of process or hazardous circumstance	Hazardous Event Scenario	Description of process or hazardous circumstance
Mining Plant	Vehicle impact - Heavy vehicle haul truck being driven down a haul road or (decline) - Cat 789 (230 T)	Loss of brakes due to mechanical fault	Impact causes fire. Hydraulic hose bursts resulting in a fire that creates a toxic atmosphere
		Loss of brakes due to electrical fault	Impact causes fire. Hydraulic hose bursts resulting in a fire that creates a toxic atmosphere
		Loss of brakes due to lack of maintenance - worn pads	Impact causes fire. Hydraulic hose bursts resulting in a fire that creates a toxic atmosphere
		Loss of steering caused by electrical fault	Impact causes fire. Hydraulic hose bursts resulting in a fire that creates a toxic atmosphere
		Conveyor starts up remotely without warning causing entrapment with moving parts (Tail Drum)	Impact / movement causes fall from height
		Conveyor starts up remotely without warning causing entrapment with moving parts (Rollers)	Impact / movement causes fall from height
Conveyor	Conveyor Maintenance / Repair - Conveyor XYZ	Emergency stop fails to operate due to malfunction when conveyor starts up remotely without warning causing entrapment with moving parts (Tail Drum)	Impact / movement causes fall from height
		Poor isolation practices. Conveyor is inadvertently started by another operator. Conveyor starts up without warning causing entrapment with moving parts (Tail Drum)	Impact / movement causes fall from height
		Poor isolation practices. Conveyor is inadvertently started by another operator. Conveyor starts up without warning causing entrapment with moving parts (Rollers)	Impact / movement causes fall from height
		Explosion causes unstable ground support conditions and during bolting process causes major failure of support structures	Ground support failure causes in-rush of water and semi solids
		Explosion causes unstable ground support conditions and during bolting process causes major failure of support structures	Ground support failure causes gas outburst
		Explosion causes unstable wall conditions and during bolting process causes major failure of support structures	Wall failure causes gas outburst
Explosion	Production blasting	Explosion causes unstable ground support conditions and during bolting process causes major failure of support structures	Ground support failure causes rock outburst
		Explosion causes unstable wall conditions and during bolting process causes major failure of support structures	Wall failure causes rock outburst
		Bench or batter design is inadequate and causes collapse	Mining plant - dredger collapses due to unstable ground conditions
		Bench or batter construction is inadequate and causes collapse	Mining plant - dredger collapses due to unstable ground conditions
		Maintenance of bench or batter is inadequate and causes collapse	Mining plant - dredger collapses due to unstable ground conditions
Slope stability	Bench or batter is inadequate and collapses	Heavy mine vehicle has a loss of brakes caused by mechanical fault. Vehicle goes through windrow and falls significant distance	Heavy mine vehicle has impact with other mine plant
Mining Plant	Windrow construction (height and width) is inadequate		

Appendix 4: Example of Mining Hazards Key Words

Activities / Processes	Procedures	Plant and Equipment	Substances	General hazards	
Design	Isolating equipment	Conveyors	Cyanide	Noise	Illegal activities
Construction	Working at height	Haul Trucks	Diesel	Vibration	Terrorism
Commissioning	Welding	Jumbo	Petrol	Biological	Natural disasters
Operation	Working in a confined space	Dredge	Anfo	Hydraulic	Rosters
Mining	Working with hazardous substances	Concentrator	Solvents	Electrical	Shift work
Inspection	Transport	Treatment plants	Silica	Thermal	Downsizing
Development	Welding	Explosives transport vehicle	Shotcrete	Stability	Visitors
Processing	Mechanical access	Personnel transport vehicle		Toxic	Unauthorised access
Maintenance	Bolting	Water Carts		Contact with moving parts	Power failure
Transportation	Repair	Scrapers		Manual handling	
Training	Use of hand tools	Drill rig		Radiation	"too much"
Mine records	Baring down	Auger		Ground support failure	"not enough"
Supervision	Traffic management	Hand held power tools		Abandoned workings	"too hot"
Risk Assessment	Working in isolation	Back hoe		Fire	"too dark"
Hazard Identification	Blasting	Dozer		Explosion	"poor"
Monitoring	Emergency response	Ventilation structures	General issues	Collapse	"poor light"
Review	First aid	Ground Support		Inrush	"poor ergonomics"
Audit	Training, Accreditation and competency	Scaffolding	Biological hazards	Wind blast	"poor control"
Response	Drugs and Alcohol	Pipes	Fatigue	Floor heave	"lack of"
Safety Assessment	Mine entry	Cables	Drugs	Gas outburst	"lack of supervision"
Documentation	Equipment specifications	Electrical installations	Alcohol	Mine gases	"lack of guarding"
Compliance	Purchasing	Fencing		Cutting / shear	"lack of training"
Reporting	Maintenance	Barriers		Impact	
Security of site	Ventilation	Pumps		Crushing	"inadequate"
	PPE	Cranes		Trapping / entanglement	"inadequate training"
	Trenching	Platforms		Roll over	"inadequate procedures"
	Electrical installations	Slings		Burns	"inadequate supervision"
	Filling	Hoists		Fumes	"inadequate design"
	Evacuation	Supports		Dust	"uncontrolled"
		Training cables		Mist	"uncontrolled movement"
		Graders		Inhalation	"unrestricted"
		Access		Biological	
		Fencing		Visibility	
		Emergency services		Mechanical	

Appendix 5: Example Risk Management Plan

Mine Name:

Date: [completed/updated]

Completed by: [name of author/s]

Approved by: [name of responsible line manager]

1. Introduction and Context

Key information to include:

- Details of the location and type of the mine
- Broad description of the mine and major activities that is subject to the Risk Management Plan.
- Key dependencies and relationships.
- Statement of objectives to be achieved (goals, critical success factors or strategies) that are relevant to the mine.

2. Risk Identification and Assessment

Key information/documents to include:

- Details of methods and processes used, people consulted and data relied on, to identify and assess risks and controls. Other sources of information contained in completed documents should also be recorded.
- Risk Profile
- Summary Risk Rating Table

3. Risk Treatments

Key information/documents to include:

- Risks ranked as low: list these risks and current controls
- Risks ranked as medium: list these risks and specify treatment process with details of program to monitor risks and review existing controls
- Risks ranked as high list these risks and specify treatment process adopted focusing on detailed monitoring program to maintain excellent/good controls and append detailed Risk Treatment Plans

4. Implementation, Monitoring and Reporting

Key information to include:

- Actions and resources required to implement the Risk Management Plan and individual Risk Treatment Plans
- Key dates and deadlines for commencement and communication
- Key staff members responsible for successful implementation
- Processes and dates for monitoring risks and treatments (in particular, major risks and 'control-critical' risks)
- Date for review of Risk Management Plan and/or Treatment Plans

5. Approvals

Key information to include:

- Name and position of those involved in preparing key Risk Management Plan documentation.
- Name and Signature of Line Manager/s responsible for the program.

Appendix 6: Team Based Risk Assessments

The steps for undertaking a team based risk assessment are detailed in the check list below:

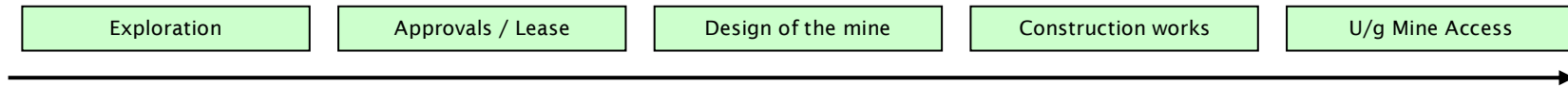
1	Determine application and scope <ul style="list-style-type: none"> ▪ Expectations of the group clearly understood and signed off ▪ Roles of the Facilitator, Team Leader and Team Members explained ▪ Discuss and understand methods / processes to be applied ▪ Identify risk criteria for your workplace
2	Analyse the Subject <ul style="list-style-type: none"> ▪ Define the process, system, plant / equipment, operation or work area to be assessed ▪ Break down the process into bite sized chunks
3	Identify unwanted events <ul style="list-style-type: none"> ▪ Identify all events likely to have a significant impact. They can be categorised as: <ul style="list-style-type: none"> ▪ Active or task related hazards ▪ Passive or systems related hazards
4	Identify existing risk controls <ul style="list-style-type: none"> ▪ Identify all existing controls that are currently in place and used
5	Determine the maximum reasonable Consequences and Likelihood <ul style="list-style-type: none"> ▪ Determine the likelihood of the event and the consequences according to the risk criteria ▪ Calculate the level of inherent risk using the risk matrix ▪ Rank or prioritise the inherent risk level
6	Assess the adequacy of the controls <ul style="list-style-type: none"> ▪ Decide whether or not the existing controls are adequate or minimise the risk ▪ Consider the number of controls in place and how effective they are
7	Determine if the risk level is acceptable <ul style="list-style-type: none"> ▪ Compare the inherent risk level against risk criteria and identify acceptable and unacceptable risks
8	Determine additional controls <ul style="list-style-type: none"> ▪ Use the hierarchy of control to determine additional controls

Appendix 7: Example of a Risk Register

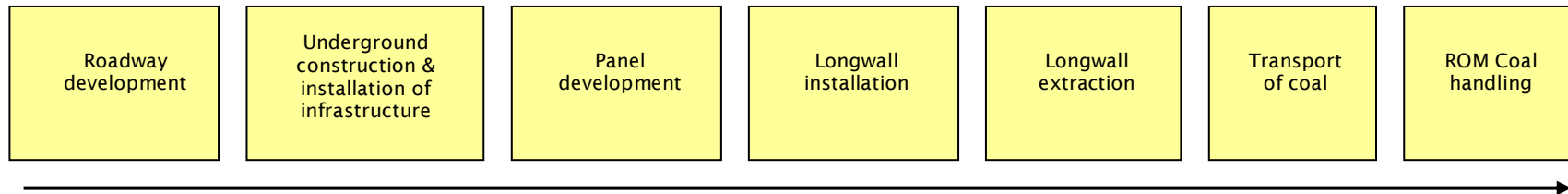
Risk Assessment - XYZ Mine										
Date:										
Participants:										
Ref No	Hazard	Potential Causes / Events	Consequences	ASSESSMENT			SAFEGUARDS			
				C	L	R	Existing controls	Additional controls	Person responsible	Due date
1	Surface cracks	Mining Subsidence	Property damage no likely human injury	1	4	5	Fence subsidence areas, warning signs, mine design			
2	Noise	Drilling	Hearing loss	3	5	15	Engineering controls on drill rigs and machinery, PPE, procedures			
3	Roof fall whilst bolting roof	Unstable ground conditions	Operators struck by significant quantities of roof material - Multiple Fatality	5	2	25	Roof support rules, inspections, bolting procedures, risk assessment,			

Appendix 8: Life Cycle Map – Underground Coal Mine

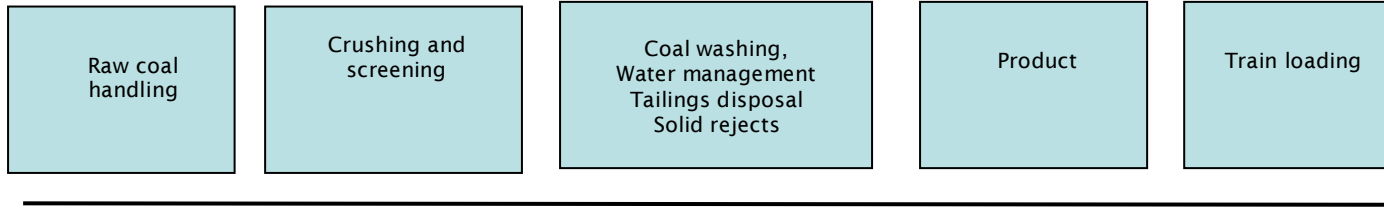
1. Mine Development and Establishment



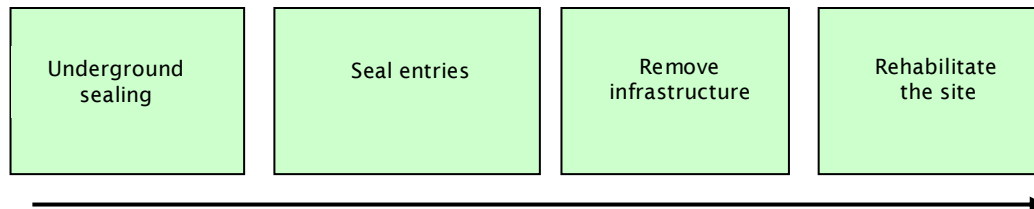
2. Operation of the Mine



3. Coal Handling and Preparation

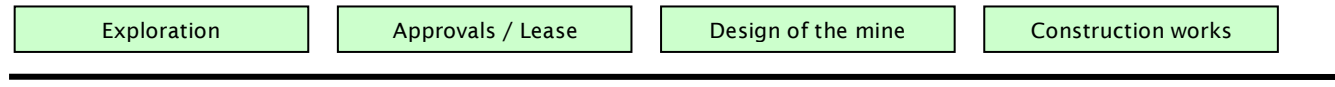


4. Decommissioning of the Mine

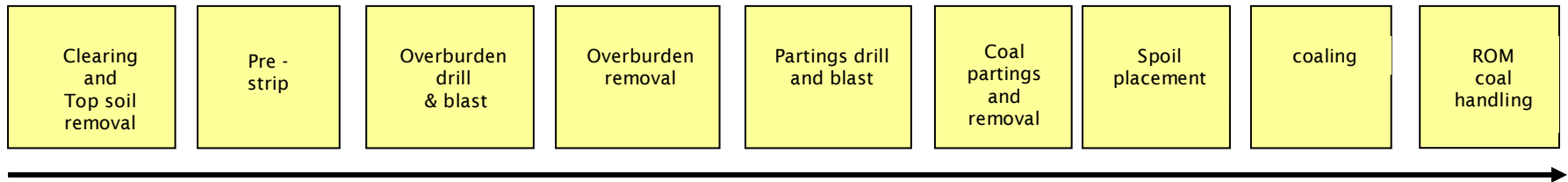


Appendix 9: Life Cycle Map – Open Cut Coal Mine

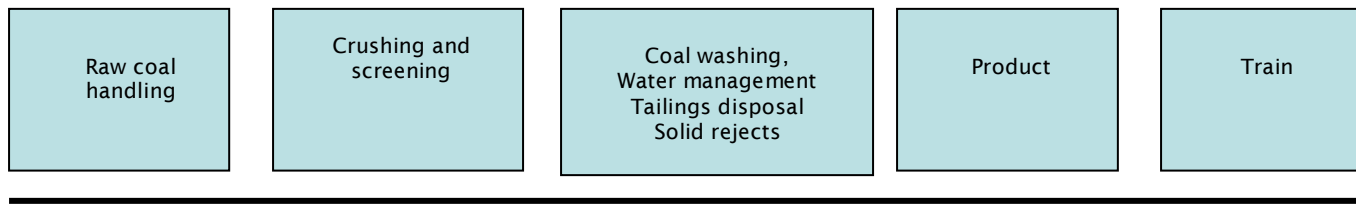
1. Mine Development and Establishment



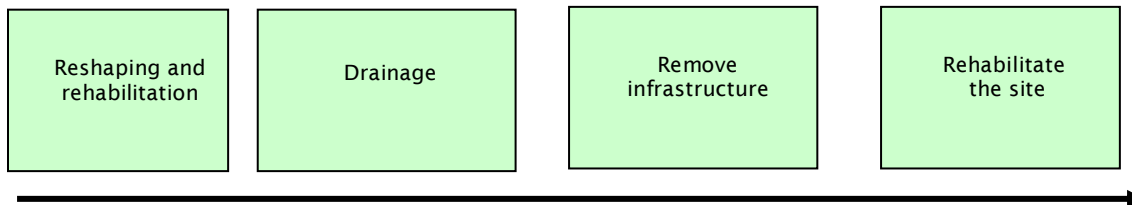
2. Operation of the Mine



3. Coal Handling and Preparation



4. Decommissioning of the Mine



Appendix 10: Government Resources

Natural Resources and Water - Queensland Government

The Department of Natural Resources and Mines – Queensland web site has a section specifically designated to deal with mining health and safety issues. The site has a various hazard alerts, safety and health publications, manuals, hazard spread sheets, hazard data base and publications section.

<http://www.nrw.qld.gov.au/resourcenet/>

<http://www.nrw.qld.gov.au/mines/index.html>

Department of Consumer and Employment Protection – Western Australian Government

Resources Safety is a Division of the Department of Consumer and Employment Protection. A key role of Resources Safety is to promote best practice in the areas of safety and health with companies (and their employees) involved in dangerous goods, mineral and onshore petroleum industries. This is achieved by educating and regulating industry through the administration of various Acts.

<http://www.docep.wa.gov.au/ResourcesSafety/index.html>

Department of Primary Industries – New South Wales Government

The role of NSW Department of Primary Industries' Mine Safety program is to provide the framework and direction to industry to manage risks through consultation and safe systems. Mine Safety works closely with employers, employees, other government agencies and the community to promote best practice in the area of mine safety. Through the verification of appropriate safety systems, processes and standards Mine Safety strives to be an efficient and effective regulator, encouraging those who exceed minimum standards and holding accountable those who do not. Mine Safety also aims to significantly improve the safety performance and culture of the industry through communication strategies and measures of performance.

<http://www.dpi.nsw.gov.au/minerals>

Department of Primary Industries – Victorian Government

The Department of Primary Industries (Vic) currently regulates mines in Victoria. New arrangements for the regulation of occupational health and safety (OHS) across Victoria's earth resource industries, including mining, quarrying and onshore petroleum production, were announced on October 24, 2006 by the Minister for Energy Industries and Resources. The Victorian WorkCover Authority will formally take on regulatory responsibility for the sector under the *Occupational Health and Safety Act* and the *Dangerous Goods Act* in January 2008.

<http://www.dse.vic.gov.au/dpi/index.htm>

Appendix 11: Australian Industry Associations

Minerals Council of Australia

The Minerals Council of Australia is taking a leadership role through the implementation of a strategy, pursued by the Safety and Health Committee, which is designed to improve the industry's safety and health performance.

<http://www.minerals.org.au/>

Minerals Industry Safety and Health Centre

Minerals Industry Safety and Health Centre (MISHC) is specifically designated to deal with mining health and safety issues. The site has a number of risk management papers available for download.

Web site: <http://www.mishc.uq.edu.au/>

Queensland Resources Council

QRC plays a leadership role in health and safety issues. The web site has various articles regarding mining health and safety.

<http://www.qrc.org.au/>

The Chamber of Minerals and Energy of Western Australia (CME)

The Chamber of Minerals and Energy of Western Australia (CME) is the peak resources sector representative body in Western Australia. The CME's Occupational Safety and Health program focuses on:

- Embedding risk management principles in all activities
- Advocating for legislative reform
- Recognising and promoting best practice
- Facilitating development of safety and health competencies at all levels

<http://www.cmewa.com.au/index.php>

Coal Services Pty Ltd

Coal Services Pty Limited (CSPL) was formed on 1 January 2002 and is committed to creating a safer, healthier workplace. It merged the activities of the former Joint Coal Board and the Mines Rescue Board into one company with responsibility for providing workers' compensation, occupational health and rehabilitation and mines rescue services to the New South Wales coal industry. The web site has numerous OHS reports and publications.

http://coalservices.com.au/index.php?option=com_content&task=view&id=2&Itemid=27

Appendix 12: International Government OHS Agencies

International Labour Organisation

The web site for the International Labour Organisation. The ILO web site has many safety related conventions and recommendations including, C176 Safety and Health in Mines Convention, 1995, C155 Occupational Safety and Health Convention, 1981 and R164 Occupational Safety and Health Recommendation, 1981. The site has publicly available guidance material and codes of practice at

Web site: <http://www.ilo.org/public/english/protection/safework/cops/english/index.htm>

- Safety and health in open cut mines
- Health and safety management systems
- Drug and alcohol management

Web site: <http://www.ilo.org/>

European Agency for Safety and Health at Work

The web site for the European Agency for Safety and Health at Work. The site has a full search engine and many downloadable publications, reports and case studies. The site has many publications and links on accident prevention. The site has extensive links to other European Safety Agencies.

Web site: <http://europe.osha.eu.int/>

Canadian Centre for Occupational Health and Safety

Canadian Centre for Occupational Health and Safety web site (CCOHS) is an EHS information service governed by a tripartite council representing the federal, provincial and territorial governments of Canada, employers, and labour. The site consists mainly of directories for other information and service providers. The site does not have publicly available guidance material relating to hazard identification, risk assessment or risk management in the mining sector. The site has links to other safety related web sites.

Web site: <http://www.ccohs.ca/>

OHS Service New Zealand, Department of Labour

The web site for the Occupational Safety and Health Service of the Department of Labour, New Zealand has a search function and an extensive library of publications. The site has hazard specific identification and risk assessment information in various codes of practice, major hazards guidance identification, assessment and control (including hazop information) many of the documents are loadable). The site has links to other safety related web sites.

Web site: <http://www.osh.dol.govt.nz/>

Health and Safety Executive – United Kingdom

The web site for the Health and Safety Executive – UK. Comprehensive site that has large amounts of publicly available guidance material specifically relating to hazard identification, risk assessment or risk management including a guide to risk assessment requirements, five steps to risk assessment and ALARP.

Web site: <http://www.hse.gov.uk/>

Department of Labor – United States of America

The web site for the US Dept of Labor is a general OHS web site that links to the Department of Labor – Mine Safety and Health Administration - United States. The site provides general information and basic “e-tools” regarding hazard identification, assessment and control. The site has a search function and extensive links to other research institutions, risk management sites, mining legislation and mining industry related web sites.

Web site: <http://www.osha.gov/>

Department of Labor – Mine Safety and Health Administration – United States of America

The Department of Labor – Mine Safety and Health Administration - United States web site is specifically designated to deal with mining health and safety issues. There is a specific safety and health page with a large amount of accident prevention material, safety tips and accident statistics. There is no general guidance material publicly available on hazard identification, risk assessment or risk management in the mining sector. There is no overall hazard listing for mines. The site has a search function and extensive links to other research institutions, risk management sites, mining legislation and mining industry related web sites.

<http://www.msha.gov/>

Risk Assessment Information Systems – United States

The RAIS web site is sponsored by the U.S. Department of Energy (DOE), Office of Environmental Management contains risk assessment tools, procedures and information including a risk readiness review checklist and risk assessment tutorial. The site has links to affiliated organisations. The site is not specifically focused on OHS.

Web site: <http://risk.lsd.ornl.gov/index.shtml>

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