Trade & Investment
Mine Safety

GUIDELINES

MDG 1010

Minerals industry safety and health risk management guideline

Produced by Mine Safety Operations Branch

January 2011

FIRST PUBLISHED: May 1997

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Foreword

This handbook provides information to assist personnel working in the minerals industry, departmental personnel and personnel working in associated industries. Information is provided to assist in the process of risk reduction and risk management.

This handbook supersedes the May 1997 MDG 1010. Since the initial publication of MDG 1010 many reference documents have been upgraded (for example AS/NZS ISO 31000:2009 Risk management - Principles and guidelines) and others have been created where previously there was a void (for example the National Minerals Industry Safety and Health Risk Assessment Guideline). Reference documents currently available provide an excellent foundation for risk assessment and risk management. For this reason the focus of MDG 1010 has spread to assist the reader in the systemic and cultural aspects of risk management within the minerals industry. We have however also produced a product to service small minerals operations. This product "Risk Management Pocket Guide" is available through departmental sales outlets.

The contribution made by the following people in the authoring and the compilation of these documents is gratefully acknowledged. They include Professor Jim Joy (Queensland University), Graham Terrey (Mine Resilience Pty Ltd) and many New South Wales, Department of Industry and Investment, Mine Safety Operations personnel. It is anticipated that the handbook and pocket guideline will be reviewed from time to time and updated as appropriate.

Comments on any aspect of this handbook including those for consideration in future additions will be gratefully appreciated. A feedback sheet is available at wwwdpi.nsw.gov.au and at the back of this guideline.

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Chapter 1 Introduction

1.1 Purpose of this guideline

This guideline replaces MDG 1010 (1997) “Risk Management in the Minerals Industry”. It has been designed to assist minerals industry sites with the development of an effective risk management system. It is not designed to specifically assist other industry organisations such as Original Equipment Manufacturers (OEMs) or suppliers. However, the principles and methods are in many cases transferable.

The content is organised to walk the reader through the relevant terminology and several basic to complex models of risk management approaches. Since every site is different, the guideline provides an easy to use approach to achieving a resilient, integrated risk management system. The “journey” to this goal is provided based on the Hudson Ladder (Hudson, 2001) illustrating that the development of effective risk management systems involves several step changes. The Hudson Ladder also provides a clear link between improvement in the culture of the organisation and the development of a systems approach.

As such this guideline does not provide an expectation for a specific risk management approach but rather a resource to assist companies and sites with the development of their own systems over time.

A final detailed image of a fully integrated risk management system is provided in this guideline to assist readers with the definition of their own future goals.

1.2 Structure and contents of this guideline

The guideline is structured to introduce the topic to sites at the very early stages of applying risk management, as well as those across the range of application points.

Chapter 2, The Risk Management Process, is intended to help the reader get a clear understanding of the words and concepts of risk management. There is also an introduction to the “fit” of risk management into a managers activities and an overview of risk assessment practice.

Chapter 3, The Risk Management Journey, provides an easy to apply image of a step-by-step journey from a reactive, “no care” management approach to a “way-we-do-business”, resilient management system. The image has 5 steps that illustrate the stages of improvement in both culture and systems. As such, it provides an opportunity to identify a sites current stage and to plan for reasonable improvements.

Chapter 4, A Model of Integrated Risk Management, offers a detailed model of a fully integrated risk management system that might be found at the top

step of the image given in Chapter 4. This section is intended to assist with developing a goal for a minerals site by discussing the activities and outcomes that might be in place.

Chapter 5, References, and Chapter 6, Appendices, provide sources of further information, as well as tools to assist the reader in the development of an improved risk management system.

1.3 Relevance to Acts and Regulations

Risk management is a common requirement of Australian mine safety and health law that is generally supported by guidance material and an industry body of knowledge such as this guideline. Prosecutors and legal practitioners examine the actions of people in assessing and managing risk. Judges see risk management as a proactive strategy and their findings commonly reflect a societal expectation that risks are effectively managed. Consequently, legislation commonly requires a general duty to manage risks.

Source: Rio Tinto Coal Australia – Kestrel Mine

A review of legal cases and legislative frameworks and practices suggests that a 'best practice' approach to meeting legal obligations for risk management requires attention to the following broad principles:

1. Proper diligence must be exercised at all levels in an organisation to identify hazards that exist or could conceivably exist to cause harm or damage.
2. Mine owner/management oversight must demonstrate commitment to systematically managing risk, provide adequate level of resources including information, instruction, training and competency development, and supervision.
3. A site that can demonstrate the effectiveness of site systems and capabilities in adequately managing risks may be required to meet objectives for specified risks while being exempted from meeting specific controls measures relating to those risks.
4. Hazard identification must be robust, appropriate and timely in relation to the site and in relation to tasks, or any type of unwanted energy release. Hazards must be distinguishable and give rise to clear risk assessments through good consultative processes.
5. Responses to risk assessments may involve:
   (a) tolerating the risk;
   (b) accepting a level of risk while constraining it to an acceptable level or actively taking advantage and regarding the uncertainty of the opportunity to gain an acceptable benefit;
   (c) transferring the risk by adopting a different approach that gives rise to an acceptable level of (lower) risk;
   (d) terminating the activity giving rise to the risk; and
   (e) regulations (or legislation, which might also call up a code of practice) might prescribe the hierarchy of risk.
6. Regulations might call up an approved code or a recognised standard such as MDG 1010 and AS/NZS ISO 31000, as well as specific codes for key risks.
7. The detail and level of effort involved in assessing the likelihood and consequence of a hazard becoming a real threat should be commensurate with the level of exposure to the hazard and the complexity of the site, task or mining practice, and take account of data or information from the site, from across industry or from an authoritative source.
8. The risk management approach determined from the risk assessment process must be:
   (a) reasonably practicable; and
   (b) consistent with and confirm company and site commitment to the systematic management of risk even though the taking of action in relation to those risks may be prioritised.
9. Risk management must involve making informed decisions and plans or procedures and must involve management oversight and supervision.
10. Risk management activities must involve
    (a) a monitoring of:
        i. the hazard;
        ii. relevant triggers or mechanisms of failure for the hazard;
        iii. respective control measures;
    (b) and must also involve

i. making adjustments to plans or procedures
ii. verifying the effectiveness of the precautions taken.

11. Risk management must exploit consultative opportunities to effect occupational safety and health improvements to site and company systems, involving reviews of risk management objectives, strategies and approaches. A range of people who are closely associated with the risk must be consulted.

In summary, risk management is the current basis of Australian mining law, and as such, a site's risk management approach has potential legal implications. However, this guideline is not intended to provide a compliance check. Rather it attempts to assist sites to go beyond regulatory requirements since legislative provisions and regulatory practices are evolving and judgments may take industry culture into account.

1.4 Relationship to Standards and Guidelines

Australia has been a leader in the development of Standards and Guidelines for risk assessment and risk management. International standards align well with the initiatives undertaken in Australia that began in the mid-1990's. Even before that the NSW Government through the then Department of Mineral Resources integrated risk management approaches into a series of helpful Mining Design Guidelines (MDG) covering many areas of equipment design and including version 1 of this guideline, MDG1010:1997 "Risk Management in the Minerals Industry".

This guideline has been written to align and expand on information found in AS/NZS ISO 31000, AS4804:2001 and ISO documents related to health, safety and environment management systems.

This guideline also links to the National Minerals Industry Safety and Health Risk Assessment Guideline (NMISHRAG), as well as the hazard management information located in MIRMgate, the Minerals Industry Risk Management gateway. Both resources can be found at www.mishc.uq.edu.au.

The definitions of terms found in Australian Standards will be consistent in this guideline, unless specifically noted. Models of risk management from Australian standards have been expanded to assist with clarity and relevance to the historical development of risk assessment and risk management in the Australian minerals industry.

1.5 Key points from this Chapter

The key points from Chapter 1 include the following:

- This document replaces NSW MDG1010:1997 titled Risk Management in the Minerals Industry.
- The content of this document is intended to assist the minerals industry with the "journey" to successful adoption of risk management methods, rather than provide a definitive expectation for a management system.

- Though this document has not been written specifically to address the detail of Acts and Regulations, some content is relevant to meeting regulatory requirements.
- This document is consistent with AS/NZS ISO 31000:2009 but some modifications to models in the Standard have been made to improve clarity specific to the minerals industry.

Chapter 2 The Risk Management Process

2.1 The rationale for risk management

The purpose of applying a risk management process might be best described as an attempt to proactively and systematically reduce losses. Of course the previously discussed regulatory issues contribute to the rationale for risk management. However, risk management was not developed by regulators. It was developed by industries and companies to improve performance.

The basic rationale for risk management continues to be the need to improve performance. Though industry safety and health performance has greatly improved in the past two decades, the frequency of major unwanted events still exceeds community expectations.

To address the need to improve, risk management should be focused on improving the quality of decision-making. There are thousands of decisions made at all levels of an organisation every day. Some decisions may be related to larger issues such as mine feasibility or mine design, while other decisions on the site concern methods of work or accomplishing the task at hand. Many site decisions can potentially lead to the assumption of significant undesirable risk.

The "Nertney Wheel" (Bullock, 1979), illustrated below, offers a model of an ideal work process for achieving safe production - the intended outcome of most site decisions. The wheel identifies four components of a safe and productive work process, competent people, safe work practices, fit for purpose equipment and a controlled environment.

Diagram 2A – The Work Process Model or the Nertney Wheel

The term **competent people** is intended to not only refer to competency related to training and skills but also appropriate motivation and "fitness for duty".

Safe work practices refers to the availability of appropriate clear expectations for the work process. This might include plans, procedures, guidelines or some other document. This is not to suggest that a procedure is required for every task. In many cases, especially where task sequence is not relevant, expected practices or guidelines may be more suitable. For example, the operation of a haulage truck may not be defined by procedure but rather a list of documented practices relating to areas such as reversing, parking locations and "crossing over" when loading.

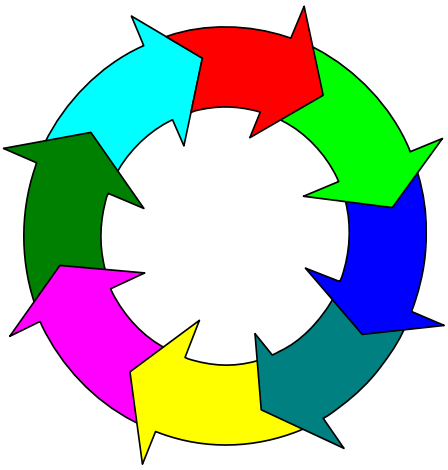
The term **fit for purpose equipment** is intended to suggest that a safe and productive work process will include equipment, plant or materials that are well designed, maintained to a set standard and made available as appropriate to the work process. Poorly designed equipment will compromise the work process as easily as inappropriate practices or incompetent personnel.

The **controlled work environment** refers to both physical factors and supervisory control in the work process. All work processes occur in some environment where conditions such as lighting, ventilation, traffic control, ground control, etc. affect safety and health in the process. Supervisory control refers to the need for the work process to be defined, directed and checked. The effective role of the "supervisor" is key to a quality work process.

The Nertney Wheel is a basic model of a safe and productive work process that can be understood by all minerals industry personnel. It also provides a clear set of goals for a risk management process. Some engineering and management decisions lead to the design and development of work processes. Some day-to-day decisions by supervisors and workers affect the risk during execution of the work process. Risk management activities should be applied in the development and execution of a safe and productive work process.

The development of a safe and productive work process is most effectively initiated early in the "life cycle" of its components. As such "life cycle" is another important concept in the application of a risk management process.

The Life Cycle Stages of a Project



- Project Concept
- Project Feasibility / Sanction
- Project Design
- Construction / Acquisition
- Commissioning
- Operation
- Maintenance
- Modification
- Disposal / Closure

Diagram 2B – The Life Cycle Stages of a Project

All four parts of the work process have a life cycle. Perhaps the easiest component to illustrate is “fit for purpose equipment”. A piece of mobile equipment has a life cycle that begins with its concept and design, ending with disposal. Reduction of risks related to the operation and maintenance of mobile equipment is most effectively addressed in the concept and design phase, especially in economic terms. For example, the reduction of fall risks through better access design is much easier when reviewing design plans than at a later point in the life cycle when a series of incidents indicates that equipment modifications are required. The same logic applies to the development of procedures and practices, plans related to work environments and work planning/supervision systems.

Therefore the rationale for a risk management process at a site is to improve performance. This is achieved by proactively developing and applying, in an effective (by focussing on the work process) and efficient (by considering the life cycle) manner, a safe and productive site.

2.2 The basic risk management process

The first step in understanding risk management involves becoming comfortable with the terminology and the intention of risk management.

Obviously correct use of the word “risk”, considering its definition, is important to successful risk management. Risk is defined as “effect of uncertainty on objectives" (AS/NZS ISO 31000:2009). This definition has evolved over the last 10 years, improving its clarity.

AS/NZS ISO 31000:2009 also notes that “Risk is often characterized by reference to potential events and consequences or a combination of these”. For the purposes of this guideline, the identification of an unwanted event will be separated from the term “risk”. The term “risk” will be used to describe

only the measure of event consequences and likelihood. Note that a risk is usually thought of in terms of negative impact but similar approaches can be used to identify positive events or opportunities.

It is important to note that there is no “zero risk”. A source may suggest that risks must be eliminated but unless the hazard is totally removed and no related hazard put in its place, elimination cannot be achieved. Risk is managed to a level of acceptability or practicality. Further discussion on establishing the acceptability of risk can be found in Section 2.3, as well as the National Minerals Industry Health and Safety Risk Assessment Guideline (NMIHSRAG). [www.mishc.uq.edu.au]

Source: Rio Tinto Coal Australia – Blair Athol Mine

The term “hazard” is defined as “a source of potential harm”. The minerals industry has many large and sometimes complex hazards. Using this definition, electricity, large mobile equipment, ground and objects at height all have a potential for harm. This guideline, in conjunction with the NMIHSRAG, suggests that good risk management involves the identification and understanding of hazards, the establishment of potential unwanted events related to those hazards and, subsequently, the analysis of risk related to the unwanted event. Using this approach risk is a measure of concern; used to increase awareness, set priority or determine acceptability of an unwanted event risk.

For example, large mobile equipment is a hazard that can manifest itself in an unwanted event such as a collision with a light vehicle parked in close proximity. By considering risk, that is some measurement of likelihood and consequences of the event, the site might establish whether current controls are adequate or new actions required.

Risk identification is defined as the “process of finding, recognizing and describing risks" (AS/NZS ISO 31000:2009). In essence this involves defining the unwanted event and associated circumstances. Successful definition of the unwanted event firstly requires identification and understanding of the hazard. In some cases hazards are clear and easy to understand but this is not always the case.

Risk analysis is defined as a “process to comprehend the nature of risk and to determine the level of risk” (AS/NZS ISO 31000:2009). In other words, this is the step where likelihood and consequence are somehow estimated. Risk analysis is usually done considering the impact of existing controls though there are circumstances where estimating inherent risk, or risk without controls, is desirable.

Risk evaluation is the “process of comparing the results of risk analysis with risk criteria to determine whether the risk and/or its magnitude is acceptable or tolerable” (AS/NZS ISO 31000:2009). Depending on the objective of the risk analysis, that is whether the objective is awareness, priority or acceptability of risk, risk evaluation should assist with the decision-making.

AS/NZS ISO 31000:2009 defines risk assessment as the “overall process of risk identification, risk analysis and risk evaluation” as outlined above. In practice, most risk assessment involves the application of a variety of informal and formal, qualitative and quantitative methods to assist with the management of risk. The NMIHSRAG, supported by the Minerals Council of Australia and revised at least annually, provides extensive assistance with the design and execution of risk assessments. This risk management guideline will not attempt to replicate that information but rather deal with risk assessment as a generic methodology within the overall risk management approach. Links to NMIHSRAG are noted where relevant.

Risk management is defined as the “coordinated activities to direct and control an organization with regard to risk” (AS/NZS ISO 31000:2009).

AS/NZS ISO 31000:2009AS/NZS ISO 31000:2009 also provides definitions for the process and framework for risk management. This guideline has expanded the risk management process model offered in AS/NZS ISO 31000:2009AS/NZS ISO 31000:2009 to more clearly link to minerals industry applications.

Minerals Industry Risk Management Process
(modified version of AS4360:2004)

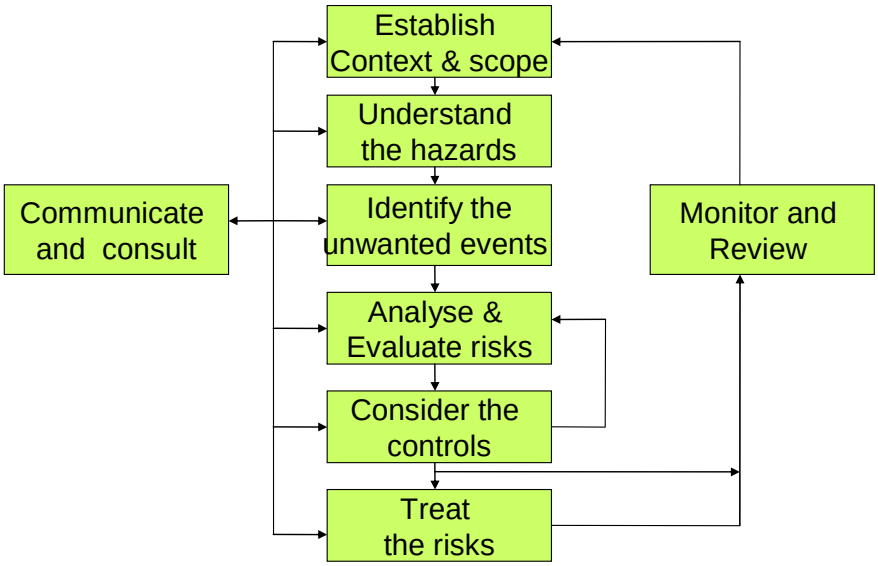


Diagram 2C – Minerals Industry Risk Management Process

It is important for all minerals industry personnel to be comfortable with the nature and logic of the risk management process. The process applies to major corporate decisions as well as day-to-day decisions by individual workers who are confronted with, for example, a change in work environment.

The above model (Diagram 2C) provides a step-by-step process that can be integrated into all relevant decision-making in the minerals industry where threats to health, safety, assets, production, the environment, community relationships and other areas are potentially present.

The need to **communicate and consult** is paramount to the entire risk management process. Consultation through involvement and open communication is a clear feature of successful risk management systems. Because of this, the "communicate and consult" box has a prominent place in the risk management process.

Establishing the context within the risk management process involves the overall direction setting and rationale for the entire process. AS/NZS ISO 31000:2009 includes consideration of external and internal factors in establishing context as well as the resultant goals, objectives and strategies including definition of risk acceptability criteria.

This guideline is designed to provide information that will help the company or site establish its goals and step-by-step objectives for achieving those goals. It remains for the company or site to understand and consider their relevant external and internal context.

The above model (Diagram 2C) also mentions establishing the **scope**. Scope is a term used for a document specifically outlining the design of a risk assessment or a series of related risk assessments including at least the risk assessment objective, boundaries, methodologies, resourcing and timeframe. This aspect of setting the context has been highlighted in this minerals industry model due to studies of risk assessment problems in the industry. As such, before starting to systematically manage risks by understanding the hazards, we must set the organisational/site context for risk management as well as the specific scope for the risk assessment.

Understanding the hazards has also been added to the model suggested in AS/NZS ISO 31000:2009. Like the scope issue, review of current industry risk assessment practices has indicated that hazards, though recognised, are sometimes not completely understood before unwanted events are identified and risks analysed. Therefore this step has been added to highlight its importance.

As mentioned before, a hazard is defined as “a source of potential harm” (. When managing health and safety the “energy” concept is an accepted method of proactively identifying sources of potential for harm. Health and safety is mainly concerned with damage to people either due to an immediate event or long term exposure. In order to physically damage a person resulting in injury or illness, the energy concept suggests that there must be an unwanted release of energy.

There are many types of energy and this guideline does not intend to suggest a complete list. However the list below was developed by a large Australian mining house to illustrate energy sources.

Common Mining Energies

Biological	bacteria, viruses, contagious diseases, natural poisons, etc.
Chemical	coal, gases, fuels, lubes, degreasers, solvents, paints, etc.
Electrical	high voltage, low voltage, batteries, etc.
Gravitational (objects)	falling coal, rock, tools, components, structures, etc.
Gravitational (people)	falling from or into equipment, structures, ladders, sumps, etc.
Machine (Fixed)	powered by electrical, hydraulic, pneumatic, combustion, etc.
Machine (Mobile)	haulage trucks, LHDs, service vehicles, gen sets, tools, etc.
Magnetic	(handling metal objects in strong magnetic fields)
Noise	from machines and other sources
Object	pressurised systems, cylinders, springs, chains, flying bits, etc.
People	slip, trip, lift strain, push/pull sprain, repetitive /postural strain
Thermal	conducted (contact) , convected (airstreams), radiation
Vibration	from vehicles, equipment, tools, etc.
Other	friction, wind, animal, bio-chemical

All of the listed energies can do damage if there is a loss of control. The specific amount and nature of the damage is determined by factors such as **the nature of its destructive potential, the mechanism for release, the**

magnitude of the energy released and the situation. For example, large pieces of mobile equipment are obviously major energy sources when moving around the mine. If a large vehicle is reversing toward another parked machine, the mechanical or momentum energy of the vehicle can do damage. The magnitude of the energy depends on the size of the vehicle and speed of movement. The nature of its destructive potential is obvious. The vehicle at speed can cause extensive physical damage to people or plant. Investigating the nature of the hazard is probably not as critical to mobile equipment because the energy and its magnitude are obvious.

If we consider a more complex hazard such as spontaneous combustion in an underground coal mine, the hazard may not be as clear. Propensity for spontaneous combustion varies with the nature of the coal and seam conditions as well as the operating environment of the mine. Without a history of events, it is possible that a significant propensity to spontaneous combustion may not be recognised. Compared to large mobile equipment there may be a much higher degree of uncertainty related to the existence, nature and magnitude of the spontaneous combustion hazard. The existence of uncertainty relating to any aspect of the hazard increases the likelihood that subsequent risk assessment and management will be inaccurate. Hence the suggestion in this minerals industry model that risk management explicitly ensure that a hazard is either understood with high certainty or, if uncertainty cannot be resolved, the hazard is managed with a conservative approach.

A simple example of conservative approaches to managing a hazard can be found in surface mines to control the potential impact of rainfall or water ingress due to rainfall. In this case the mine usually establishes a 1 in 50 or 1 in a 100 year rainfall event, designing the pit to control or at least economically survive the impact. The defined level of the hazard, the 1 in 50 rainfall, may never happen in the life of the mine. However, it is recognised that uncertainty about rainfall must be managed by this approach where the potential consequences of inrush or flooding are major.

Once the hazards are recognised and understood, with uncertainty addressed, unwanted events can be identified. This step in the model, **identify the unwanted events**, was found to be a problem in the minerals industry. Identification of unwanted events must be systematic in order to be thorough. Thorough risk identification is key to the application of most risk assessment methods. These methods attempt to ensure that a systematic approach is used to examine the issue, process, design or location by requiring step-by-step, component-by-component or process node by process node review. Sometimes this systematic approach is replaced by unstructured brainstorming leading to gaps in risk identification. More information in this area is available in the NMIHSRAG. [www.mishc.uq.edu.au]

Once the specific unwanted events have been clearly defined in terms of its nature and consequence, the process can proceed to its next step; **analyse and evaluate risks**. There are a variety of methodologies that combine likelihood and consequence to determine risk. Several examples are provided in the NMIHSRAG [www.mishc.uq.edu.au]. Of importance is the

clear establishment of the objective of the risk analysis. There is probably no single method of risk analysis that applies effectively to all possible objectives related to increasing awareness, setting priority and determining the acceptability of risk.

As mentioned previously the analysis of risk may or may not include consideration for existing controls. It is probably more common to analyse risks considering existing controls but when developing risk registers or considering a novel design or work process, it may be desirable to estimate inherent risk or risk without controls in place.

The next box in our risk management process (Diagram 2C) is **consider the controls**. The following Hierarchy of Control, adopted in many regulatory approaches, offers a good framework for considering the effectiveness of controls. Note that the effectiveness of a barrier that is intended to reduce a risk decreases from top to bottom of the list. In other words, the closer the barrier type is to the top of the hierarchy, the more potentially effective the control.

- Eliminate the hazard or energy source (do not use the energy)
- Minimise or replace the hazard or energy source (reduce the amount of energy to a less damaging level or replace the energy with another that has less potential negative consequences)
- Control the hazard or energy using engineered devices (e.g. lock outs, chemical containers, mechanical roof support, gas monitors, etc.)
- Control the hazard or energy by using physical barriers (e.g. machine guarding, warning signs, etc.)
- Control the hazard or energy with procedures (e.g. isolation procedures, standard operating procedures, etc.)
- Control the hazard or energy with personal protective equipment (e.g. hard hats, boots with toe caps, gloves, safety glasses, welding gear, etc.)
- Control the hazard or energy with warnings and awareness (e.g. posters, labels, stickers, verbal warnings, etc.)

The feedback loop in the model to **analyse and evaluate risks** is intended to indicate that this is an iterative process. Depending on the risk assessment scope and methodology, at some point existing controls will be considered, as well as any potential new controls to establish residual risk.

The model provides a connecting arrow after **consider the controls** to the **monitor and review** feedback loop. This pathway would be appropriate if no new controls were required based on the risk analysis. If the existing controls are adequate it may still be necessary to monitor and review the hazard and control status to ensure that the risk remains acceptable.

Treat the risks is intended to indicate a step where new controls have been identified and applied. Past studies of industry risk assessment also indicate issues with effective application of new controls. Therefore the application of results from the risk assessment to the workplace is highlighted by this step.

Monitor and review refers to the critical need for ensuring that existing or new controls are in place, as well as ensuring that the hazard or conditions that might affect the risk have not changed. Monitoring and reviewing can be informal or formal. Auditing is a common formal review process. Incident and incident investigation is also a review process triggered by an unwanted event. As such, auditing and investigation are risk management tools.

Change in hazards or the status of controls is a major contributor to accidents in the minerals industry. Again this area was often found to be weak in industry risk assessment studies.

2.3 Risk acceptability and risk management

One of the most challenging concepts in risk management concerns the establishment of risk acceptability. There is no zero risk if a hazard is truly or potentially present. Risk must be managed to a level that is as low as reasonably practicable (ALARP).

The UK Health and Safety Executive offer a helpful explanation of risk acceptability.

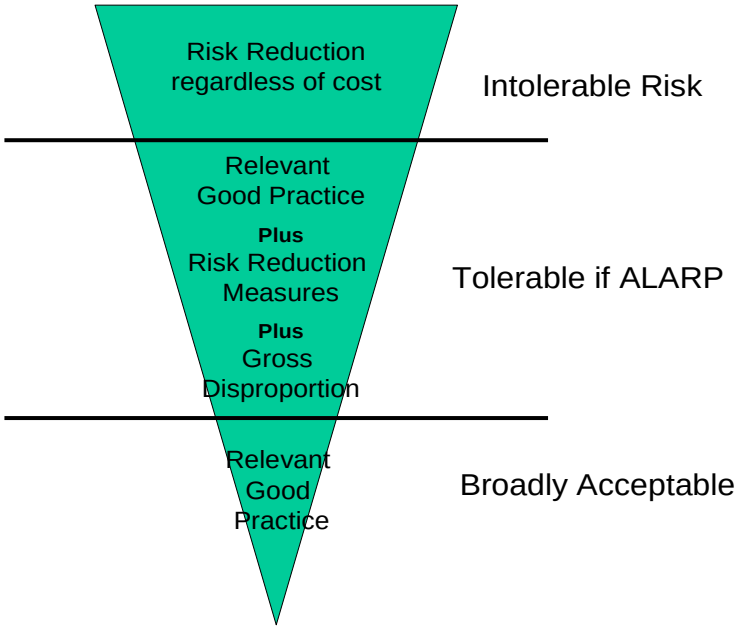


Diagram 2D – Risk Acceptability

The above illustration is taken from "Guidance on 'as low as reasonably practicable' (ALARP) Decisions in Control of Major Accident Hazards (COMAH)" (UK HSE, 1999). It is intended to show levels of ALARP demonstrations.

The inverted triangle shape of the illustration is intended to indicate increasing risk from the bottom to the top. The top, or the highest level of risk, is termed

“Intolerable Risk”. The related HSE document suggests that if a risk is in that region ALARP cannot be demonstrated and action must be taken to reduce the risk irrespective of cost. The document also cites that an intolerable individual risk to a worker is one that is greater than a 1 in 1000 chance of death in a year.

The second region, “Tolerable if ALARP”, involves the requirement to establish ALARP by demonstrating that the controls are sufficient for and proportionate to the risk. The individual risk suggested in the UK HSE document for this second region is between 1 in 1000 and 1 in 100,000.

In the “Broadly Acceptable” region, ALARP can be demonstrated based on adherence to codes, standards and established good practice that is relevant and up-to-date.

In practical terms, the HSE model suggests that risk must be managed to ALARP. It also demonstrates that establishing ALARP is based on the level of unmanaged or inherent risk. The higher the level of inherent risk, the greater the need to demonstrate that the controls are effective for accomplishing ALARP.

Objectively establishing the inherent risk to the worker may be difficult. Data suitable for calculations is limited for establishing whether a mine worker’s risk related to a specific hazard or event is 1 in 1,000 or 1 in 10,000. This limitation makes establishment of ALARP with quantitative risk analysis methods usually difficult.

It is probably more efficient to approach the establishment of ALARP by either estimating risk with controls in place using semi-quantitative methods or establishing that the controls provide an effective level of risk reduction. Although these approaches sound similar, in practice they may involve very different methods.

Establishing ALARP by calculating residual risk, the remaining risk after all required controls are in place, involves the application of an appropriate risk analysis method that offers a clear and logical approach to justifying a reduction in the inherent risk to a level of acceptable residual risk.

Many existing qualitative “five by five” risk matrices that supply levels of event likelihood and consequence do not provide the clear and logical approach required to demonstrate ALARP. As such, the practice of “re-ranking” risk with such a risk matrix may lead to error in estimates of residual risk.

Some semi quantitative methods that consider other dimensions of risk such as exposure and the likelihood of maximum reasonable consequence may offer an opportunity to demonstrate ALARP. In this case, the risk analysis method may provide an effective approach to analytically demonstrate the decrease in risk due to the application of a set of required controls. That set may include various controls, some of which reduce the likelihood of the event, while others reduce the likelihood of the consequences. For example,

driver training and good road design reduce the likelihood of a vehicle collision. A seat belt decreases the likelihood of maximum reasonable consequences. The basic “five by five” tables cannot consider the two types of controls.

For the selected risk analysis technique to be useful for demonstrating ALARP it is essential that it can clearly and validly demonstrate the risk reduction value of controls. The “Hierarchy of Control” mentioned in the previous section indicates that some controls are more effective than others. A risk analysis method intended to demonstrate that a residual risk is ALARP must provide a valid method for valuing the risk reduction impact of various types of controls.

Establishing ALARP by demonstrating that controls are adequately effective involves a different method than risk analysis. In this case the focus is on establishing that the set of controls provide an adequate level of protection for the inherent level of risk or consequence.

Recent developments in this area only use risk or consequence analysis to establish a level of required control analysis. This approach is easy to understand if we consider the HSE illustration provided above. In this model there are three categories of risk; intolerable, tolerable with ALARP and broadly acceptable.

A control effectiveness analysis approach might establish that the set of controls was suitable for the category. An example from NASA is provided in the NMIRAG [www.mishc.uq.edu.au]. In this example inherent risk is established by a risk analysis method and control effectiveness is determined by a different method. The value of the control is then matched to the level of risk to establish its adequacy. Although the NASA method is a good example that clearly illustrates a method of establishing individual control effectiveness, it is also necessary to look at the cumulative impact of a set of controls to determine ALARP.

For the potentially “intolerable” and “tolerable if ALARP” risk levels, it is essential to establish that the specific control set is adequate, including consideration of their availability and reliability. Obviously comparison of control sets to best practice is valuable in these regions. A hazard management information database such as MIRMgate [www.mirmgate.com] might be helpful for this comparison.

For the broadly acceptable region, demonstration of adherence to codes, standards and accepted good practice should be adequate.

Whatever method is selected to establish ALARP, the objective is to clearly answer the question – is the control enough for the risk? The question must be answered for ALARP to be demonstrated. If the question is effectively answered and ALARP is established the worker, the manager, the board member, the regulator and the community should be comfortable that the site is being managed to an acceptable level of risk.

Once the reader is comfortable with the basic steps in the risk management process, establishing the acceptability of risk and other relevant concepts such as the Nertney Wheel and Life Cycle, the context of risk management within the manager's role and site or corporate systems can be developed.

The concept of ALARP is also dealt with in UK NOPSA (National Offshore Petroleum Safety Authority) Guidance Note N-04300-GN0166.

Source: Rio Tinto Coal Australia – Hail Creek

2.4 Relationship between operational management and risk management

Establishing the context of risk management within the manager's role is the first step in developing an image of a risk management system.

The law establishes that roles in the management of risk exist across the workplace, including workplace related designers and suppliers. The manager needs to recognise that it is part of his or her role to manage risks. Experts in the area of health, safety, the environment or community affairs can facilitate the manager's understanding of the hazard, as well as factors that contribute to risk and good practice controls, but the manager must take accountability for ensuring that a quality risk management process is undertaken. At the

individual level the role of the manager has been described in many ways. Peter Drucker (1970) and others have provided a simple image of a manager as a person who undertakes four activities.

1. Planning
2. Directing
3. Checking
4. Adjusting

If a manager agrees that his or her role involves these generic activities then an effective understanding of risk management may come from linking risk management related activities to these four general management activities. The following illustration provides a simple link.

Management & Risk Management

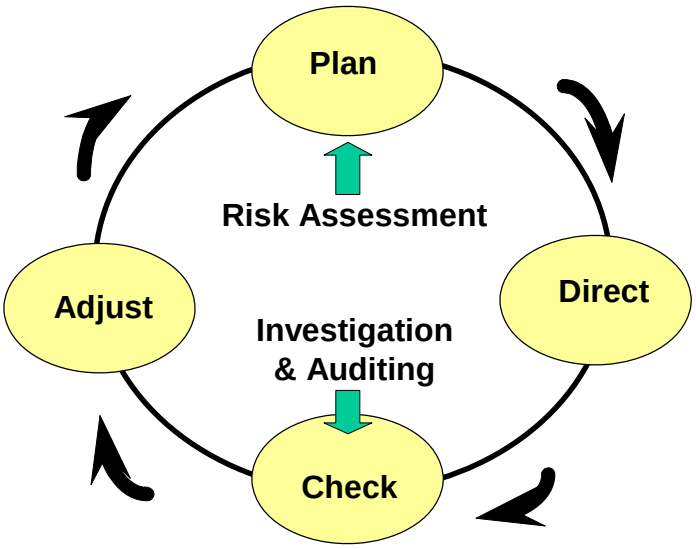


Diagram 2E – Management and Risk Management

The illustration links three risk management activities, risk assessment, investigation and auditing, to the plan, direct, check, adjust model.

Risk assessment involves many of the central steps shown in the risk management process outlined previously. Investigation and auditing are two approaches to monitoring and review, another step in the risk management process. A manager should see the value of applying risk assessment to important planning such as the development of designs, procedures, mine plans, resourcing etc. As a result, the output of the planning activity should be a safer and more productive workplace.

If the manager accepts that checking is an important activity then he or she should establish both the method of checking and the relevant expectations to be checked. If the planning activity has produced a safe and productive expectation then it may be important to check that there is adherence.

Monitoring or auditing to that expectation is a mechanism for checking. Deviations from expectations are addressed by the manager in the fourth activity, “adjusting”.

Investigation of unwanted events is also a method of checking. If a safe and effective expectation was derived in the planning activity and an incident or accident has occurred then there was either a problem with adherence to the expectation or a problem with quality of the expectation itself. In both cases the manager, as in the auditing area, would address any findings in the fourth activity, “adjusting”.

This simple image of the risk management activities, as they apply to a manager, is intended to anchor risk management in the roles and responsibility of every manager in the minerals industry.

The next section of this guideline will expand on the area of risk assessment. If the reader would like to move on to further understanding of the risk management context for the manager and the site management system he or she should go to section 2.6.

2.5 Risk assessment and risk analysis: tools for managing risk

A previous section stated that risk assessment is the “overall process of risk identification, risk analysis and risk evaluation” (AS/NZS ISO 31000:2009). Risk analysis was defined as a “process to comprehend the nature of risk and to determine the level of risk” (AS/NZS ISO 31000:2009). Both are tools for managing risk and, as such, only a part of the risk management process. Risk assessment and analysis without the other aspects of risk management is ineffective.

Formal risk assessment has a long history in some industries. For example, the petrochemical, nuclear, military, aviation and space industries have applied various formal risk assessment techniques for over 30 years. Today all of these industries would see risk assessment as an inherent part of their business.

This systematic proactive approach to improving risks in an industry, as opposed to a reactive “fix-it-when-it-breaks” mentality, was most often suggested after major disasters such as the Flixborough chemical plant disaster (1973), Three Mile Island nuclear plant event (1979) and others.

Risk assessment has had a significant history in the Australian minerals industry, though not as lengthy. The Australian industry has applied formal, systematic risk assessment more extensively than minerals industries in most, if not all, other countries. With a history of over 15 years in many parts of the industry, there has been rapid growth in the use of the tools.

Risk assessment tools offer systematic approaches that can assist with key decision making in the minerals industry. Although regulatory authorities

promote and in many cases require risk assessment, these tools are an inherent part of sound business management, not only an ethical or legal obligation.

The accuracy and effectiveness of risk assessment deliverables can vary greatly depending on the quality of the risk assessment process. The MCA guideline, NMISHRAG [www.mishc.uq.edu.au], provides guidance for those intent on following an effective approach to risk assessment in their operations. In the body of NMISHRAG, there are a number of Internet links and reference sources of further information on the guideline topics.

This Risk Management document includes some of the content in the NMISHRAG to assist readers with an understanding of risk assessment. However, for more complete information refer to the NMIRSHAG.

As the definition suggests, risk assessment involves several steps identified within the red box shown below in the previously outlined process model.

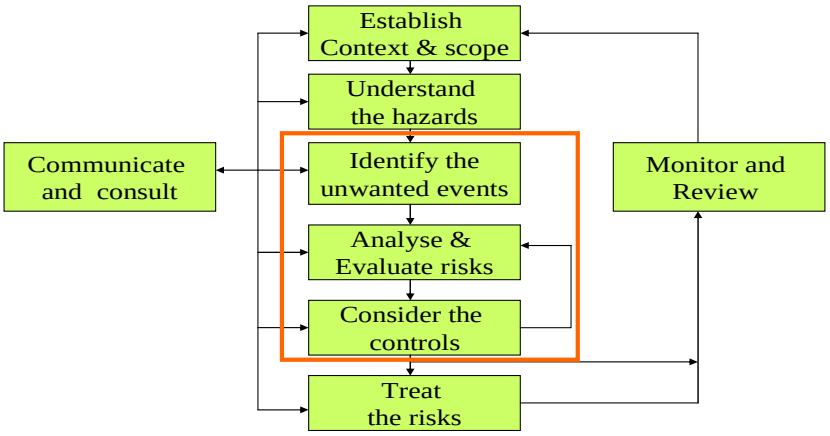
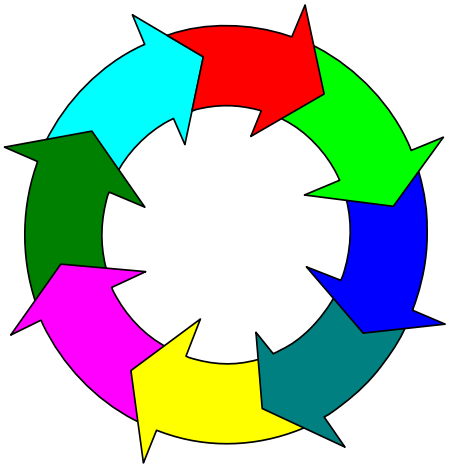


Diagram 2F – Minerals Industry Risk Management Process with Risk Assessment Highlighted

As suggested by the model, context setting, scope development and hazard understanding must occur before the risk assessment.

The timing of a risk assessment depends of the required deliverable but the general principle is the earlier the better. Sometimes the use of a life cycle approach, discussed earlier, can be helpful to consider the timing of risk assessment.

The Life Cycle Stages of a Project



- Project Concept
- Project Feasibility / Sanction
- Project Design
- Construction / Acquisition
- Commissioning
- Operation
- Maintenance
- Modification
- Disposal / Closure

Diagram 2G – The Life Cycle Stages of a Project

The Life Cycle, as suggested previously, illustrates the various stages in any project. The most cost effective timing for risk assessment is usually the concept/design phase. Risk assessments are often done at an early point in each life cycle stage.

Minimally, the timing of risk assessment should allow time for a quality analysis, as well as time to effectively apply the deliverables from the analysis.

Again, the NMISHRAG provides more guidance on risk assessment and the life cycle [www.mishc.uq.edu.au]

2.5.1 Scoping a risk assessment

Risk assessment workshops, held to identify risk assessment quality issues, identified that there are two major keys to success in a risk assessment:

- A good understanding of the hazard; and
- A well designed risk assessment (a good **Scope**).

The nature of hazard recognition and understanding was discussed earlier in this document (see Section 2.1) so the following information will focus on the design or scope of the risk assessment.

Scoping a significant risk assessment exercise, before the actual exercise meeting is held and requires consideration of at least the following areas:

- **The objective** - based on the expected deliverable
- **The system to be reviewed** - specifically the physical, process or event boundaries

- **The potential hazards** - including the degree to which they are clearly understood
- **The risk assessment method** - the means of systematically identifying and considering the risks that suits the objective
- **The risk analysis method** – the means of calculating and examining the level of risk, and considering its acceptability
- **The composition of the team** or work group
- **The time required** (and venue)
- **The format of risk assessment results** including deliverables with accountabilities and timelines

The objective of the risk assessment may be associated with one of the following intended outcomes or deliverables (note that this is not an all-inclusive list). It is important to establish the desired deliverable from the risk assessment before deciding on the risk assessment method.

- Formal Safety Assessment development (safety case)
- Risk Register development
- Risk acceptability determination
- Information for major or principal hazard plans
- Information for operational guidelines
- Information for maintenance plans or guidelines
- Hardware design review
- Option selection/review
- Review of change management plan
- Information for drafting of SOPs
- Informal risk awareness on day-to-day tasks

It is important to get a clear image of **the system to be reviewed** by defining boundaries around the system (i.e. the start and finish of a task, the cycle of a process, the parts of a design, the geographic area, etc.) that is to be reviewed using risk assessment. Boundaries define the risk assessment coverage, reducing the likelihood of overlaps or gaps. Setting the systems boundaries also helps to identify the information required for the risk assessment.

To identify risks we must understand the **potential hazards**. The quality of a risk assessment greatly depends on the recognition that:

Firstly – identify and understand the hazards
Secondly – identify the unwanted events and assess the specific risks

If the existence, nature or potential consequences of a hazard are not reasonably certain, the risk assessment should not proceed.

Source: Rio Tinto Coal Australia – Tarong Mine

To identify and understand the hazards consider:

- **Hazard identification**
  Identifying the existence and location of a potential source of harm or threat to the system objectives

- **Hazard assessment**
  Determination of the magnitude/amount/size of the hazard and thereby its potential consequences, as well as identification of any uncertainties about the nature of the hazard (i.e. lack of certainty about its nature, size, consequences, etc.)

The risk assessment exercise will identify specific potential unwanted events or circumstances but, especially in complex or major assessments, it is helpful to define the types of hazards that will be considered during the scoping process. Research, before the risk assessment exercise is convened, may be important. Note that helpful information about hazards can be found at www.mirmgate.com, a good practice source of information for hazard identification, risk analysis and good practice control identification.

To identify the specific unwanted events carefully select **the risk assessment method** or tool. It is important to consider the previously identified objective, expected deliverable, system boundaries and hazard information.

The following list and table identify relevant tools for the previously outlined deliverables, firstly by listing some risk assessment tools, then by suggesting the deliverables with which these tools can assist.

Some common risk assessment techniques for the suggested deliverables are as follows (see the NMISHRAG for more details and more methods including templates at www.mishc.uq.edu.au):

- **Informal RA** – general identification and communication of hazards and risks in a task by applying a way of thinking, often with no documentation.
- **Job Safety/Hazard Analysis (JSA/JHA)** – general identification of hazards and controls in a specific task, usually for development of a Standard Work Practice (SWP).
- **Energy Barrier Analysis (EBA)** – detailed analysis of determining phases of an events and control mechanisms.
- **Preliminary Hazard Analysis/Hazard Analysis/Workplace Risk Assessment and Control (PHA/HAZAN/WRAC)** – general identification of priority risk issues/events, using qualitative or semi-qualitative risk analysis methods, often to help determine the need for further detailed study.
- **Hazard and Operability Study (HAZOP)** – systematic identification of hazards in a processing design.
- **Fault Tree Analysis (FTA)** – detailed analysis of contributors to a major unwanted event, potentially using quantitative risk analysis methods.
- **Failure Modes, Effects and Criticality Analysis (FMECA)** – general to detailed analysis of component reliability risks.

This table suggests the risk assessment tools that can help achieve the previously discussed project or site deliverables.

Potential Deliverable / Objective	Informal RA	JSA /JHA	EBA	PHA / HAZAN / WRAC	HAZOP	FTA	FMECA
Formal Safety Assessment development			X	X	X	X	X

Risk Register development				X			
Risk Acceptability determination				X		X	
Information for major or principle hazard plans			X	X		X	
Information for operational guidelines				X	X		
Information for maintenance plans or guidelines				X	X	X	X
Hardware/ processing design rules					X		X
Option/selection review				X		X	
Review of change management plan				X			
Information for drafting of SOPs		X		X	X		
Informal risk awareness on day-to-day tasks	X	X					

Diagram 2H – Risk Assessment Tools

The risk analysis method selection involves determining the way to calculate risk considering "how often" (probability or likelihood) and the consequences (or severity).

Like the previous requirement to select the risk assessment tool, it is important to match the risk analysis method to the objective and expected deliverable.

There are three types of risk analysis methods; qualitative, quantitative and semi-quantitative. Generally the use of qualitative analysis helps increase awareness of higher risks, providing gross priority but not accurate risk acceptability guidance. Semi-quantitative will create a better understanding of risks, more sensitive priority and possibly an image of acceptability. Quantitative risk analysis, when good quality, offers a clearer understanding of the risk, more accurate prioritisation and potentially a more objective identification of acceptability. The objective and intended outcome of the analysis should determine which method is appropriate.

It is also important to consider the source and quality of the data to be used to estimate risk. Opinions, sometimes verified to some degree, are the usual data source for qualitative and semi-quantitative estimates. Quantitative analysis requires significant historical or actuarial information specific to the risk being examined. Hence the latter can be difficult and more time consuming, if possible at all.

The need to establish ALARP or the acceptability of the risk is also important when selecting the appropriate risk analysis method.

Following is more information on the three types of risk analysis methods.

Qualitative risk analysis – involves making basic risk judgements in general categories such as high, medium, low or red, yellow, green. The table below illustrates a Qualitative approach. There are 3 categories for Likelihood of an unwanted event and 3 categories for Consequence.

	High Consequence	Medium Consequence	Low Consequence
High Likelihood			
Medium Likelihood			
Low Likelihood			

Diagram 2I – Qualitative Risk Analysis

There is no significant description of the difference between high, medium or low, simply the words. Therefore it remains for the person(s) who uses this method to decide on those differences. As such, it is a very basic method of risk analysis that simply divides the identified risks into three categories – red, yellow and green.

It is not likely that any risk assessment method, other than Informal Risk Awareness for Day-to-Day Tasks, would use this approach.

Semi-quantitative risk analysis – involves risk calculation based on selection of categories, often defined by quantitative statements. Like the title suggests, semi-quantitative risk analysis uses some aspects of quantification (i.e. number values) but it also retains the categorisation approach used in qualitative risk analysis.

There are many variations on design of semi-quantitative analysis approaches. Many risk analysis matrices are used in the industry, usually offering five levels of likelihood and five levels of consequences. When developing matrices the description or numerical ranges for the levels must be carefully defined to meet objectives as well as provide discreet and suitable choices.

Other dimensions of risk may also be relevant to the Objective. Sometimes exposure is important to consider. In health and safety risk analysis, exposure is the number of times the person can be part of the unwanted event. Exposure is important when multiple work groups or multiple tasks need to be considered.

Other semi-quantitative methods might consider another dimension of risk; the variation in consequences that can occur from an event. More information on these methods can be found in NMISHRAG [www.mishc.uq.edu.au].

Quantitative risk analysis involves the calculation of probability, and sometimes consequences, using numerical data where the numbers are not ranks (1st, 2nd, 3rd) but rather "real numbers" (i.e. 1, 2, 3, 4 where 2 is twice 1 and half of 4).

Most Quantitative Risk Analysis attempts to establish probabilities for unwanted events, such as the probability of a large petroleum tank failure as a numeric probability, such as .003 failures per year. If there are multiple events that must happen before a major loss can occur then assigning these numerical probabilities allows for calculations that are normally not possible with semi-qualitative or qualitative data.

The accuracy of probabilistic data is often challenged, especially when the numbers are multiplied, potentially exacerbating any inaccuracies. Obviously the accuracy of the data is determined by the validity of the source. It is uncommon for a minerals company or organisation to have extensive probabilistic data especially where human activity is concerned. There are several commercial services that supply probabilistic data on hardware failures and some sources of human reliability data.

Consequences can be quantified by establishing a common unit for all of the potential losses such as dollars.

More information on these methods can be found in NMISHRAG [www.mishc.uq.edu.au].

As mentioned in an earlier section, there is no zero risk if a hazard is truly or potentially present. All actions, decisions or situations involve some level of risk, though in most cases the risk is very low. Very low or reasonable risk, such as the risk of the roof collapsing in a modern office, is considered to be acceptable. Many regulatory frameworks require the management of risk to a level that is reasonable but fall short of defining the specific criteria for major unwanted events such as an occupational fatality.

In many risk assessments, especially where ALARP or risk acceptability is part of the objective, it will be necessary to determine the approach for establishing risk acceptability during the risk assessment scoping process. The required precision of the risk acceptability criteria may vary with the Objective.

If the Objective of the risk assessment does not involve specifically determining acceptability, the intent may be to identify the priorities for risk reduction. In this case the use of an accepted qualitative or semi-quantitative risk analysis technique may be adequate. The selected risk analysis

technique may supply a cut off classification where risk is seen to be “low”, requiring no additional action other than the current management systems.

If the Objective of the risk assessment requires determination of ALARP or risk acceptability, then quantitative or carefully selected semi-quantitative techniques would likely be most appropriate.

More information on risk analysis methods can be found in the NMISHRAG [www.mishc.uq.edu.au].

The composition of the team or working groups should include a relevant cross-section of personnel with varying perspectives on the system in order to provide a broad depth of experience and background to the risk assessment.

When applying risk assessment methods that involve the use of a team, a process facilitator should also be considered. All significant risk assessments should have a dedicated facilitator. As the complexity of the risk assessment increases the required skill level of the facilitator will also increase.

Obtaining an appropriate balance between the following disciplines should be pursued in team member selection:

- Management personnel with a system overview
- Technical and supervisory personnel from technical services, maintenance or production areas related to the system
- Trades and operational personnel from maintenance, production or processing plant areas
- An expert or experts in the area that is the subject of the risk assessment
- A facilitator (appropriately competent in the selected Risk Assessment method)
- A recorder or scribe (this should not be the facilitator but could be a team member who has the appropriate skills of accurate minute taking etc)

A team of between four to eight persons would be typical of a risk assessment exercise. More may be required for specialist input but the team must be kept

as small as practical so that it is able to operate as a team. "Observers" should be discouraged.

The time required for any team exercise should be specified in the scoping document as should the venue and any special requirements associated with the venue. Most risk assessments take significant time with the carefully selected team with more complex risk assessments taking longer. An average qualitative risk assessment would likely require one or two team days.

The format of the risk assessment results should construct the information to address the desired final deliverable, a Formal Safety Assessment (safety case), an Operating Plan, a SOP, etc. As previously mentioned, the Scope should define the expected process for utilising the outputs of the risk assessment.

All formal risk assessment should be documented for many reasons including the need for future reference. The specific format will vary depending on the complexity and purpose of the assessment. Minimally, it is necessary to use a scientific approach to the Risk Assessment report such as the following:

Executive Summary
Introduction
- *Context (background need, organisation and site drivers)*
- *Issues/Reason for Review*

Objective and Expected Outcomes
Method
- *Team (names, positions and related experience)*
- *Hazard description information*
- *System description and boundaries*
- *Risk assessment method*
- *Risk analysis method*

Results (tables, charts, etc.)
- *Priority risks*
- *Priority existing controls and performance indicators*
- *Priority new controls and performance indicators*

Recommended Action (the Action Plan information) including accountabilities and timelines

The draft report should be reviewed by the Risk Assessment client, finalised and, once the required actions have been completed, stored in a manner that facilitates retrieval and review.

Many Risk Assessments will require that the output include a Risk Assessment Report that includes an Action Plan listing the suggested new controls and offering an opportunity to identify specific new actions, accountability and target dates.

Table: Example Action Plan

Hazard	Existing	Recommended	Specific	Accountability	Target	Completion

Identified	Controls	New Controls	Action		Date	Date

In the above example the first three columns would be derived from the Risk Assessment output, probably by the author of the formal report. The client (or "risk owner") would ensure the Action Plan was completed.

The final Action Plan should also be included in the formal Risk Assessment report to facilitate traceability.

It may be necessary to set an Action Plan review date for some point after the Risk Assessment to ensure all required Actions are complete or on schedule.

2.5.2 Risk assessment pitfalls

Although risk assessment is a potentially powerful tool, as with all tools if it is not used with care and understanding the outcomes may well be totally or partially incorrect, leading to unacceptable outcomes.

A recent report by the UK Health and Safety Executive (HSE, 2003) examined a range of assessments and identified the following "common" pitfalls.

Pitfalls identified were:

- Carrying out a risk assessment to attempt to justify a decision that has already been made
- Using generic assessment when a site specific assessment is needed
- Carrying out a detailed, quantitative risk assessment without first considering whether any relevant good practice was applicable, or when relevant good practice exists
- Carrying out a risk assessment using inappropriate good practice
- Making decisions on the basis of individual risk estimates when societal risk is the appropriate measure
- Only considering the risk from one activity
- Dividing the time spent on the hazardous activity between several individuals – the "salami slicing" approach to risk estimation
- Not involving a team of people in the assessment or not including employees with practical knowledge of the process/activity being assessed
- Ineffective use of consultants
- Failure to identify all hazards associated with a particular activity
- Failure to consider all possible outcomes
- Inappropriate use of data
- Inappropriate definition of a representative sample of events
- Inappropriate use of risk criteria
- No consideration of ALARP arguments (i.e. using cost benefit analysis to attempt to argue that it is acceptable to reduce existing safety standards
- Not doing anything with the results of the assessment

- Not linking hazards with risk controls

A focus on quality in the scoping and execution of a risk assessment should avoid the majority of these pitfalls.

2.5.3 Connecting the risk assessment process to good practice information

Risk assessment quality is also affected by the degree to which the team is aware of effective, good practice controls for the specific unwanted event as well as the potential consequences of hazards as discussed previously. The Minerals Industry Risk Management Gateway (MIRMgate) metadata website [www.mirmgate.com] can help with hazard identification, risk analysis and control derivation.

As such, MIRMgate offers a third major resource for the development and operation of effective risk management systems.

Minerals Industry Risk Management Tool Set
(All available at www.mishc.uq.edu.au)

Diagram 2J – Minerals Industry Risk Management Tool Set

By accessing MIRMgate while scoping or designing a risk assessment, a person can access hazard and task specific information. This good practice information can assist with understanding the hazard, potential unwanted events and the level of risk, as well as providing helpful information about good practice controls and barriers.

2.6 Designing and developing the risk management system

Once managers are comfortable with the activities involved in risk management, as briefly outlined in section 2.3, and the nature of risk assessment as a set of decision-making tools, they can begin to design the risk management system.

AS/NZS ISO 31000:2009 defines “risk management framework” as the “set of components that provide the foundations and organizational arrangements for designing, implementing, monitoring, reviewing and continually improving risk management throughout the organization”. For the purposes of this guideline, this definition will be used for the risk management system.

Management & Risk Management

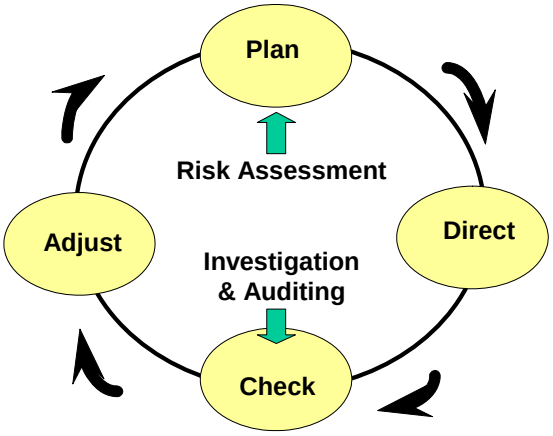


Diagram 2K – Management and Risk Management

The following management system areas broken into our previous Plan, Direct, Check, Adjust model may help to illustrate the systems approach.

1. Plan	
	Management Leadership
	Responsibilities/Accountabilities
	Risk Assessment/Management
	Compliance and other requirements
	H&S Planning and Programmes
2. Direct	
	Personnel Training and Contractor Services
	Documentation and communications
	Facilities design and construction
	Operations, Maintenance and Management of Change
	Community Awareness and Emergency Response
3. Check	
	H&S Performance Monitoring and Measurement
	Incident Investigation, Reporting and Analysis
	H&S Management Systems Audits
4. Adjust	
	Management Review and Adjustment

Ideally the organisation would design a risk management system by identifying the most important decisions made throughout the organisation with the greatest potential negative impact. For example, a "green field" site might recognise that the most important decisions are being made related to mine plan, the acquisition of equipment, the acquisition of a workforce and the relationship with the local community. It would be logical to identify where risk assessment could help reduce risks in decisions related to those areas, formalising the requirement for risk assessment as part of the green fields' development process. In an operating mine there would also be decisions about mine layout, equipment, purchasing and work methods but there may be equally important decisions being made in day-to-day work scheduling and work planning.

The above illustration, based on Plan, Direct, Check and Adjust, has been only suggested as an "image" of how systems link to the basic management model. The model in some texts has also been referred to as Plan, Do, Check and Act. It is apparent from experience that the development of such an approach to risk management does not evolve overnight. The next section of this workbook introduces a step-by-step "ladder" model based on the work of Professor Patrick Hudson. The model is intended to help an organisation identify their current status related to risk management systems and a reasonable, achievable set of improvements.

2.7 Scaling the risk management system for smaller operations

Before completing this section, the issue of size of the organisation or site versus complexity of the risk management system should be discussed.

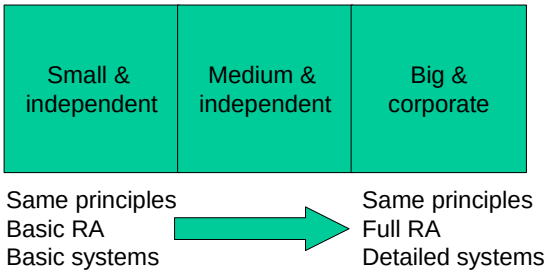


Diagram 2L – Scaling the Risk Management System for Smaller Operations

The terms "scaling" refers to the consideration of the complexity of the risk management system, based on the needs and capability of the organisation. Clearly large and complex organisations may require a risk management system described by the same terms. If there are many important decisions made in a variety of activities by a large number of people the need for defined formal expectations to suit all situations leads to the large and complex risk management system.

Anecdotal evidence in the Australian minerals industry appears to suggest that some existing large site risk management systems are seen to be overly

complex, leading to lack of understanding and adherence. This may be due to a lack of recognition that the culture and the systems must develop in parallel rather than an actual systems failure. The linkage of culture and systems is clearly outlined in the “ladder” model provided in the next section.

Assuming the culture is ready for some form of risk management system, scaling means that a balance between the size of the system and the size of the organisation needs to be achieved.

There are many extremely small operations in the Australian minerals industry including opal mines and quarries. It may not be practical for very small independent operations to develop and apply formal risk management systems in all relevant areas. In fact, smaller operations where interdependency of people is obvious may have effective informal risk management approaches. However, even a one man operation can apply the principles of the risk management process informally to decisions relating to work practices, equipment selection and work planning. The NSW Department of Industry and Investment currently supplies resources and workshop opportunities for small operators to learn about the risk management process and to apply it at a level scaled to their operations and resources.

Source: Rio Tinto Coal Australia

Small operators should contact the NSW Department of Industry and Investment to acquire resources such as:

- The generic “Mine Safety Management Plan” for opal mining;
- The JSA Development Guideline for Procedure Writing;
- Risk Management Pocket Guide

- Log book forms; and
- Information on Workshops for Small Mine Operators.

These resources with the assistance of DII inspectors will probably provide better guidance to a small operator than this guideline.

2.8 Key points from this Chapter

This section of the guideline established the foundation for development of a risk management system, providing definitions for relevant risk management terminology as well as addressing the following points:

- The risk management process should include the application of concepts such as energies, the hierarchy of control, the work process model and the life cycle.
- An effective risk management process includes an understanding of the hazard and identification of unwanted events before the level of risk can be analysed and evaluated.
- Risk assessments should be carefully designed considering the objective and the expected outcome using a scoping process to ensure the correct methodologies and resources are identified before the exercise.
- There are classic pitfalls to risk assessment that must be addressed through good scoping and quality control of exercises and reports.
- Smaller operations can also use this guideline to identify principles and basic approaches to managing risk but specific assistance is also available from other resources.
- This new guideline is one part of the available resources to persons designing risk assessments and risk management systems. Other resources are the National Minerals Industry Safety and Health Risk Assessment Guidelines [www.mishc.uq.edu.au] and MIRMgate [www.mirmgate.com], a good practice hazard information database.

Chapter 3 The Risk Management Journey

Every minerals site, in fact every workplace, applies some form of risk management. The approaches vary in detail and formality but every minerals industry site consider risks in some way when making important decisions. The degree to which the process is systematic, formal and accurate varies from site to site.

This guideline suggests a carefully designed systematic approach to managing risk that attempts to ensure all important decisions involve some approach to risk management. There is no “one hundred percent” risk management system but this guideline presents the fully integrated risk management system as a goal.

Integrated risk management involves the formal placement of risk management activities throughout the key management and engineering processes of the site, including day to day work planning and control. Currently, integrated risk management is the goal of many high hazard industries such as mining, offshore oil, aviation, nuclear power and others.

Integrated risk management should be attractive to any minerals industry company or site. However, research indicates that achieving a resilient, effective integrated risk management system requires evolution of the site’s culture and systems over time.

It would be virtually impossible for a site with limited formal risk management approaches to attempt to apply integrated risk management systems. It is necessary for the systems to evolve through a series of stages and, importantly, the culture or people factor at the site must evolve in parallel.

To assist the reader with an image of this evolution or “journey” this guideline provides a model based on work by Professor Patrick Hudson, University of Leiden (2001), modified to provide specific guidance for a company or site to move towards fully integrated risk management.

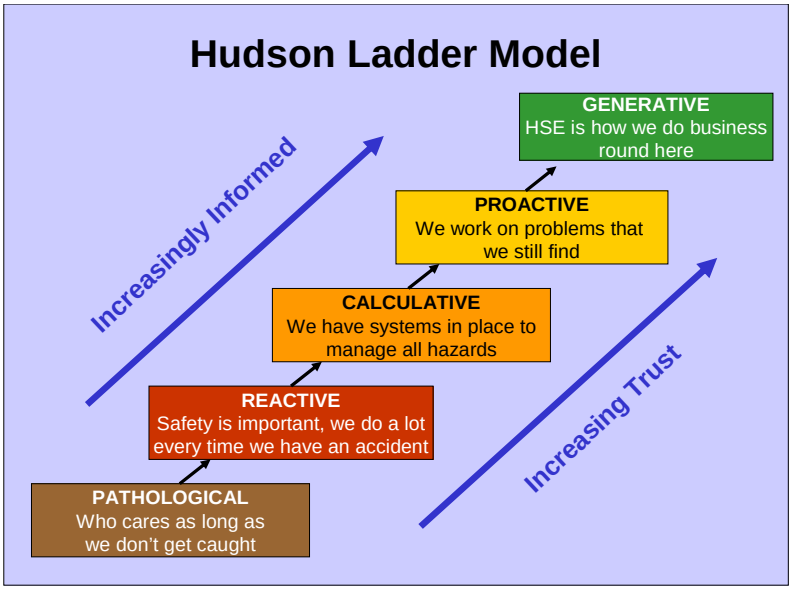


Diagram 3A – Hudson Ladder Model

The Hudson Ladder Model (SIEP BV, 2003) has been used to describe the management system's "journey" in many industries including oil, aviation and healthcare. Hudson's model illustrates a five step progression from a "pathological" site where there is a "no care" culture and "no systems" through to a "generative" stage where managing risks is a way of life and fully integrated systems are effectively in place.

The next section of this guideline will introduce a modified Hudson Ladder with specific activities relevant to Australian minerals industry sites and the risk management "journey".

3.1 Introduction to the Minerals Industry Risk Management Maturity Chart

In section 2.4 of this guideline, a link between a manager's role and the activities involved in effective risk management was established. In that section it was suggested that a manager's role involved planning, directing, checking and adjusting. Risk assessment was an activity within the risk management process clearly related to the manager's planning role. It was also put forward that incident investigation and monitoring/auditing were risk management activities connected to the manager's checking role.

A site risk management system should define where these activities occur throughout the engineering, management and supervisory processes of the site. The culmination of the defined activities across the site provides an image of the site's progress in the risk management "journey".

To facilitate a clear understanding of the journey based on a description of the culture and the risk management system a Minerals Industry Risk Management (MIRM) Maturity Chart has been developed based on the

Hudson model. The MIRM Maturity Chart might also be thought of as a "ladder".

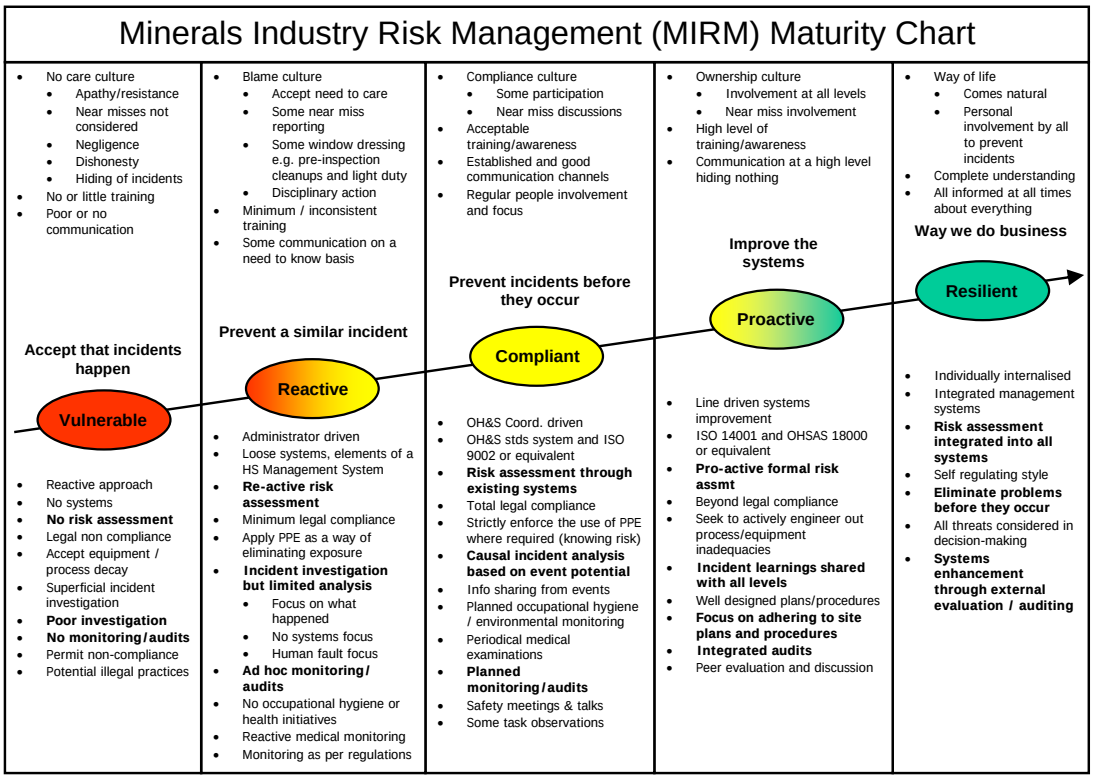


Diagram 3B – Minerals Industry Risk Management Maturity Chart

The MIRM Maturity Chart or ladder was developed considering both the Hudson Ladder and a similar approach used by Bayside Aluminium, a BHP Billiton site in Richards Bay, South Africa.

The MIRM ladder also has five "rungs". The lowest rung is called "Vulnerable" where the site will "accept that accidents happen".

The next rung or level of improvement sees the site move to "Reactive" where there is recognition that the site should "prevent a similar incident". Improvement from this rung moves the site to "Compliant" where the culture and systems try to "prevent incidents before they occur".

The next rung in the ladder is probably the largest or most profound step for any site. Movement to the "Proactive" rung involves the site, through its culture and methods, embracing the systems approach. At this rung of the ladder the system ownership genuinely moves to line management and supervision.

The final rung in the MIRM ladder is titled "Resilient". Resilient is a term used by James Reason (1997) to describe an organisation that has successfully integrated risk management into its operation, described simply in our ladder as making it "the way we do business".

Source: Port Waratah Coal Services

There are several important points that should be made about the MIRM ladder:

- The ladder suggests a rung by rung approach to the goal of a resilient management system. It is important to recognise that skipping a rung in the ladder is difficult. It is likely that a site will spend some time, perhaps years, successfully progressing from one rung to the next. The intent of including the MIRM ladder in this guideline is to assist sites in defining action plans for moving up a rung.

- The MIRM and Hudson Ladders both suggest a strong relationship between the people factor or culture of the site and the status of the systems at the site. It is critical to recognise that systems cannot progress up the ladder without culture progressing in parallel. It is likely that some of the current systems' problems experienced at sites are a result of culture/systems mismatch.

The following four sub-sections outline information to help in progressing from one rung of the MIRM to another.

It is possible for the reader to use the preceding model or a brief self assessment tool in the appendices of this document to establish the current status or "rung" where the site is operating. Note that if the culture and systems are different the lower "rung" of the two should be the assumed location of the site. With this in mind, the reader can select which of the following sub-sections are relevant to progressing his or her site.

3.2 Progressing from the Vulnerable to the Reactive rung
3.3 Progressing from the Reactive to the Compliant rung
3.4 Progressing from the Compliant to the Proactive rung
3.5 Progressing from the Proactive to the Resilient rung

3.2 Progressing from the Vulnerable to the Reactive rung

The vulnerable rung of the MIRM ladder is where the most ineffective risk management systems that can be operated short of deliberate negligence exist. A Vulnerable site would have a culture that was apathetic, uncaring, dishonest and probably highly confrontational. No risk assessment in a formal sense would be undertaken. Investigation would be limited to that required for insurance or corporate purposes and checking through monitoring and audits would be limited if done at all.

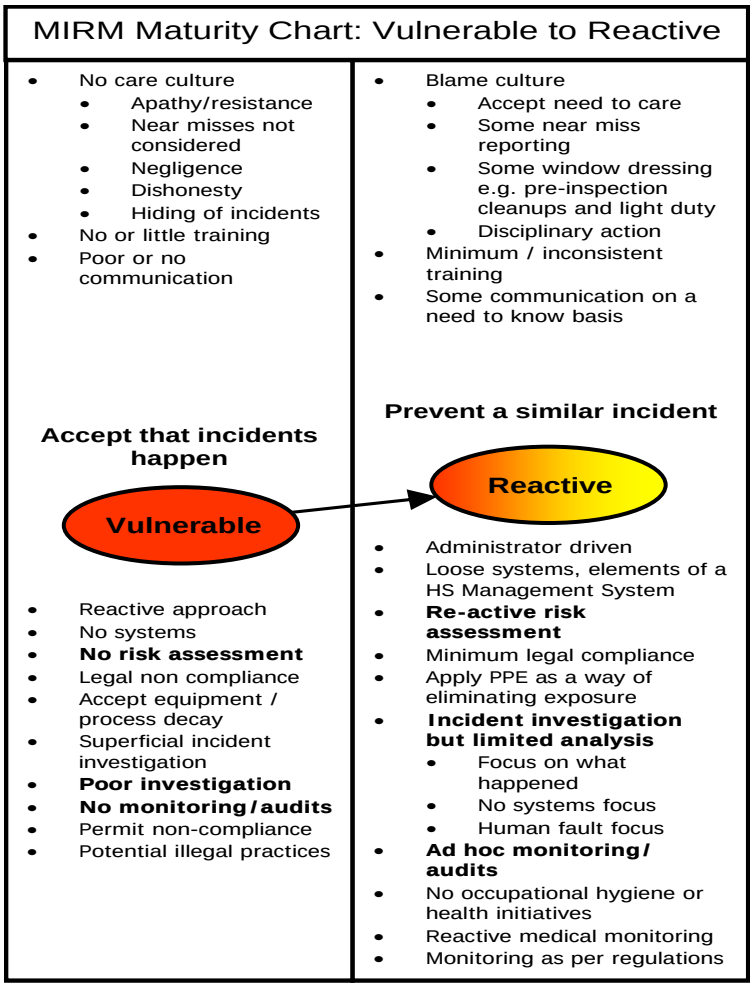


Diagram 3C – MIRM Maturity Chart: Vulnerable to Reactive

If a site establishes that its risk management system is Vulnerable then planning to move toward the Reactive rung should involve consideration of the following areas of improvement:

- Moving from a “no care” to a “blame” culture
- Beginning to think about competency and communication
- Acquiring a model of OH&S activities to develop
- Starting to do risk assessment
- Starting to consider legal compliance
- Introducing basic accident investigation

- Introducing basic inspection, monitoring and auditing

As it sounds “moving from a no care to a blame culture” is not an ideal improvement in a workplace. Unfortunately it appears that it is a necessary step in the evolution of workplace culture. As the words say, the change involves management and supervision paying more attention to work methods including unwanted events. However, it is likely that this attention will involve the “blame the bloke” syndrome.

As the model indicates, an improvement toward the Reactive rung involves an acceptance about the need to care about safety around the site. But this caring is probably limited by management’s understanding of issues related to human behaviour. Behaviour to expectations may be rare and reactive. For example, people may start cleaning up a work site because they know it is about to be inspected but the desirability of an ongoing clean work site is not accepted as a part of the culture.

Manifestations of a reactive culture also include limited recognition that training to expectations is an important part of safe production. Limited communication up and down through the organisation is also indicative of this level of culture.

To improve from Vulnerable to Reactive the culture must start to care even though it may go through a blame phase. The site should establish an approach to looking at competency and developing communication.

Risk management systems’ activities such as risk assessment, accident investigation and checking through inspection, monitoring and auditing should be started. This might be best achieved by acquiring an external health and safety management program provided by a services supplier and possibly audited by that supplier on a regular basis.

Many sites in the minerals industry have evolved through external OH&S management systems as a necessary step towards development of their own site specific system.

As the ladder suggests, systems in the Reactive phase are probably driven by an assigned OH&S administrator. If an OH&S person does not exist it may be necessary to appoint a person to this role. In the Reactive phase that person will have an active role in managing health and safety through the introduction of the external health and safety management program. Parallel to this that person may have an active role in developing legal compliance. Legal compliance is a minimum standard of risk management that must be achieved to reach the Reactive rung.

As previously mentioned the three key risk management activities within the system are risk assessment, investigation and checking through inspections, monitoring and auditing.

At the Reactive rung a site would be applying occasional formal risk assessment methods to meet regulatory requirements to address the need for improvement after an unwanted event or possibly to plan for an obvious significant change such as a new mining method or piece of equipment. It is likely that basic risk assessment methods such as Job Safety Analysis (JSA) or Preliminary Hazard Analysis (PHA), sometimes called WRAC (Workplace Risk Assessment and Control), would be used at this early stage in formal risk assessment.

The Reactive rung will likely involve the establishment of accident investigation forms and the accountability for supervisors to fill out and submit the forms after an accident has occurred. However, it is likely that a formal accident investigation procedure outlining responsibilities for analysis, action planning and follow up will not exist.

These early days of inspection, monitoring and auditing would involve the development of inspection activities to meet compliance requirements and possibly auditing to the newly introduced external occupational health and safety management program. Monitoring behaviour and the status of controls as per expectations would not be in place at the Reactive rung.

In summary moving from Vulnerable to Reactive involves the following changes:

- **Moving from a "no care" to a "blame" culture by accepting the need to care**
- **Beginning to think about competency and communication through to the development of some related activities**
- **Acquiring a model of OH&S activities approach possibly through adoption of an externally supplied OH&S management program**
- **Starting to do risk assessment for compliance, after an accident or for a major change using basic techniques such as JSA and PHA**
- **Starting to consider legal compliance and beginning to audit the site for compliance**
- **Introducing basic accident investigation through the development of forms and the supervisor's responsibility**
- **Introducing basic inspection, monitoring and auditing at least to compliance requirements and possibly auditing to the new occupational health and safety management program.**

3.3 Progressing from the Reactive to the Compliant rung

A mine site described by the Reactive rung in the MIRM ladder would have a blame culture where attention is paid to site performance but inappropriate application of discipline and a general "blame the bloke" mentality would exist. Reactive phase sites have started to develop a systematic approach to managing risk often through the purchase of an external health and safety management program that defines basic activities in risk assessment, accident investigation and monitoring/auditing.

Some sites may find that their risk management systems have progressed well beyond basic risk assessment, investigation and monitoring/auditing. However, those same sites may recognise that their culture still indicates the existence of blame, poor communication and reactive adherence to procedures. In this situation the site should consider itself to be on the Reactive rung. Systems and cultures must advance together. A site with a more advance management system but a blame culture will likely have problems with implementation, ownership and adherence to the systems.

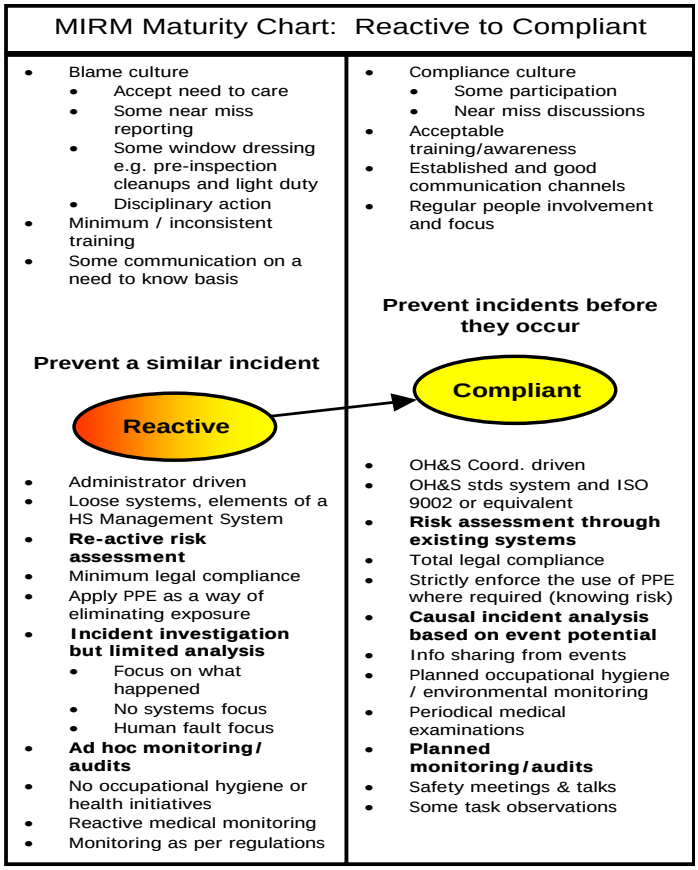


Diagram 3D – MIRM Maturity Chart: Reactive to Compliant

If the site establishes that its risk management system is Reactive then planning to move to the Compliant rung should involve the following areas of improvement:

- Moving from a “blame” to “compliance” culture
- Setting effective competency and communication systems
- Establishing an OH&S management system
- Doing risk assessment more systematically
- Meeting legal compliance
- Defining improved accident investigation and analysis
- Doing planned monitoring and auditing

Moving from blame to compliance involves a change in site culture where everyone recognises that they should comply with site expectations. This change will probably occur due to factors such as an understanding of the reasons for non-compliance and a fair discipline approach. This evolution moves the culture toward “safe production” but probably still involves some lack of acceptance that compliance is not only required but also desirable.

Source: Rio Tinto Coal Australia

The establishment of clearly more effective competency and communication approaches also supports the development of a more positive culture. Better competency and training methods provide better understanding and skills that reinforce expectations as well as providing an understanding of their necessity.

Better communication both up and down the organisation allows for issues with compliance to be addressed in a more open and constructive manner.

It is likely that the formal OH&S management program possibly originally based on an external provider’s model will begin to be modified or even replaced due to site recognition of the model’s limitations in the Compliant phase. The site may also recognise that information such as AS4804:2001 and ISO documents relating to health, safety and environmental management suggest the development of a management system rather than the operation of health and safety management programs. The latter is more about activities while the former is more about process.

For example, in the Compliant rung risk assessment will be improved by more systematic application in areas such as design, planning, procedure development and post investigation. Methods of risk assessment might be expanded from basic techniques such as JSA and PHA to more detailed methods such as Hazard and Operability Studies (HAZOP) for a process design review and Fault Tree Analysis (FTA) or Bow Tie Analysis (BTA) for in-depth consideration of specific site issues. At this point the site should

establish a risk assessment procedure that begins to outline the expected methods to be used for defined reasons with defined accountabilities.

Similarly, accident investigation would evolve from Reactive to Compliant by increasing the detail and procedural requirements of the process. A site at the Compliant rung would have an accident and incident investigation procedure requiring a level of investigation and analysis suitable to the potential as well as the actual outcome of the event. At Compliant the focus may still be on the investigation based on actual outcome but in this phase the need to examine near-hits more extensively should begin to appear.

At the Compliant rung the site should have established expectations for inspecting, monitoring and auditing that exceed regulatory compliance. These three activities should start to be systematically linked to plans. In other words, when the mine produces any planning information that information should include requirements for monitoring and auditing the plan to ensure adherence. It may be early days at the Compliant rung for accepted effective monitoring and auditing but at least the practice should have started. Inspection of physical plant and equipment may be well established in this phase.

Monitoring of behaviour to ensure adherence to expectation is likely to be recognised as a desirable activity in the Reactive phase but the existence of the compliance culture and its lack of full acceptance of the importance of the expectations may restrict acceptance of behaviour monitoring.

In summary moving from Reactive to Compliant involves the following changes:

- **Moving from a blame to compliance culture by understanding human error and developing equitable ways to address it**
- **Setting effective competency and communication systems by formalising training and opening communication channels up and down the organisation**
- **Establishing an OH&S management system by evolving the OH&S program considering site needs and guidance information such as AS4804:2001**
- **Doing risk assessment more systematically based on a defined risk assessment procedure covering what should be done, when it should be done and responsibilities**
- **Meeting (and exceeding) legal compliance by focussing on the development of an effective OH&S management system**
- **Defining improved accident investigation and analysis with a specific procedure at least introducing the concept of investigating to potential rather than actual outcomes**
- **Planned monitoring and auditing designed to check against the expectations, though acceptance may still be inadequate.**

3.4 Progressing from the Compliant to the Proactive rung

Climbing from the “Compliant” rung to the “Proactive” rung is probably best described as a change in paradigm. To make this step, people in the organisation not only accept the need to comply but begin to take ownership in the site’s expectations. The ownership culture includes everyone on the site. The ownership culture is indicated by the common interest and commitment of people to understanding, discussing and committing to safe production. It is a change of paradigm because it is a perceivable major shift in the organisation.

The move to ownership for an individual line manager might be loosely compared to experiencing a personal revelation. The line manager recognises, usually demonstrably, that the tools and principles of risk management are helpful for his or her job and for business outcomes other than health and safety. Hence the H&S department relinquishes the ownership of risk management to the line managers.

Source: Rio Tinto Coal Australia – Kestrel Mine

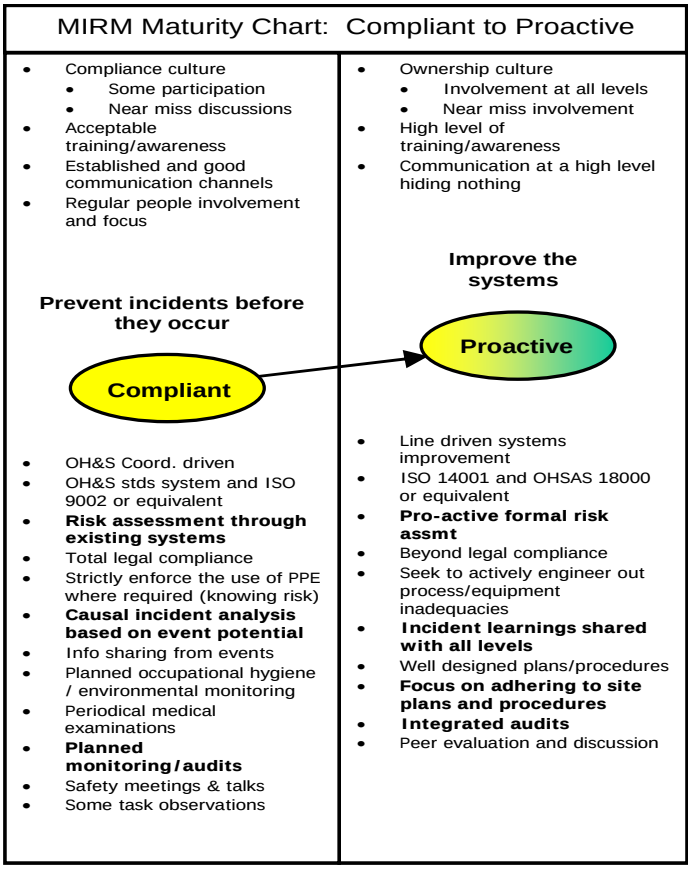


Diagram 3E – MIRM Maturity Chart: Compliant to Proactive

Moving from the Compliant to the Proactive rung is helped by the following areas of improvement but at this point the paradigm shift may be mostly about recognising that good management systems actually help people do their job rather than add additional work.

- Moving from compliance to an ownership culture
- Proactive competency and communication approaches
- An OH&S management system to AS 4804:2001
- Proactive, systematic risk assessment
- Being beyond legal compliance
- Openly shared outcomes of accident investigation and analysis
- Integrated monitoring and auditing

A site at the Compliant rung will probably have a relatively effective risk management system. The system may still be only partially adopted by managers and supervisors but this issue is probably more about the compliance culture than the detail of the system.

At the Proactive rung the systems may not change greatly but there is much greater acceptance. It may be difficult to plan for the change from Compliant to Proactive because the change may occur only because managers and supervisors overtly take ownership of the systems which cause the systems to be more effectively applied and adjusted to meet the real needs by the managers and supervisors.

For example at the Compliant rung regular, systematic risk assessment may be done as per a defined procedure. If this proves to be effective in the eyes of managers and supervisors they would evolve the procedure and the methods to more appropriately suit their specific decisions. This may occur because the manager or supervisor recognises that risk assessment actually helps them do their job. A maintenance manager may realise that Reliability Centred Maintenance, a risk based approach to maintenance, will help develop a better maintenance plan. A mining engineer might realise that careful risk assessment creates a safe and productive mining plan. A minerals processing superintendent may realise that a change in plant design without the use of HAZOP is unacceptable for both safety and production reasons.

All of these examples illustrate a personal acceptance and adoption of risk management systems as a way to effectively operate the business. In essence, the change from Compliant to Proactive is mostly about this paradigm shift in systems ownership.

Systems manifestations at the Proactive rung include competency development systems that identify needs, establish training and education mechanisms, control the quality of delivery and include mechanisms for ensuring competency is still appropriate.

Communication systems would be carefully designed to establish the best method and medium for types of messages that travel both up and down the organisation. The system would be designed to facilitate openness and honesty of the organisation.

As mentioned previously, activities such as risk assessment, accident investigation and checking by monitoring and auditing would be improved by managers and supervisors to more effectively address the priority needs of the organisation.

Monitoring behaviour may now become an established, systematic, accepted activity at the site because the ownership culture includes recognition that monitoring behaviour helps “get the job done” in a more safe and productive manner. If the individual has ownership he or she is committed to the site’s expectations and therefore deviating from the expectations is not deliberate.

In summary, moving from the “Compliant” to “Proactive” rung involves the following changes:

- **Moving from a “compliance” to an “ownership” culture because everyone recognises that management systems help the job get done in a safe and productive manner. This may require that the benefits of risk management systems be measured and overtly demonstrated to line managers.**
- **Evolving proactive competency and communication approaches, carefully designed with a systematic approach considering needs,**

application and feedback loops, overtly including features that demonstrate openness and leadership

- **Evolving the OH&S management system to AS4804:2001 by improving the site management system through the committed input of the managers, supervisors and employees that "own" the system.**
- **Evolving the proactive, systematic risk assessment based not only on the procedure but also the insight of the responsible managers and supervisors**
- **Moving well beyond legal compliance with a defined risk management system where compliance though complete is secondary to having systems that suit the site**
- **Openly sharing outcomes of accident investigation and analysis where investigation of potential high consequence events is actively pursued allowing for open and honest sharing of causal information**
- **Establishing integrated monitoring and auditing, again tuned to address the priority issues of the business as indicated by the managers and supervisors and workers that own the process.**

3.5 Progressing from the Proactive to the Resilient rung

The move from the Proactive to the Resilient rung is probably the easiest step on the ladder. Once an ownership culture has been achieved moving to "a way of life culture" is more about optimising the management system than changing the culture. Establishing a culture where the management of risk is "the way we do business" means combining the positive ownership culture with a system that is tuned to the exact needs of that culture and the organisation so that the positive culture is combined with an effective and user-friendly system of work.

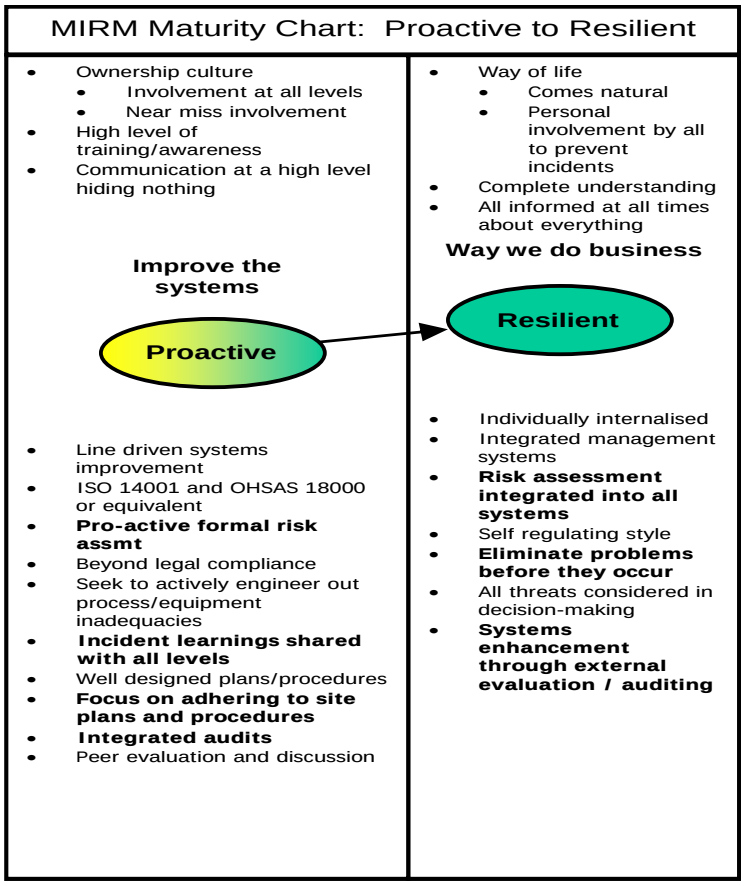


Diagram 3F – MIRM Maturity Chart: Proactive to Resilient

Like the previous steps on the ladder the move to Resilient involves consideration of several areas:

- Moving from an ownership to a way of life culture
- Totally open communication approaches
- Fully integrated risk management systems
- Risk assessment integrated into key systems
- Total focus on eliminating problems before they occur
- Third party auditing

James Reason (1997) suggests that a Resilient culture is informed, reporting, just, flexible, learning and also wary.

- An *informed culture*: one which those who manage and operate the system have current knowledge about the human, technical, organisational and environmental factors that determine safety of the system as a whole.
- A *reporting culture*: a culture in which people are willing to report errors and near misses.
- A *just culture*: a culture of no blame where an atmosphere of trust is present and people are encouraged or even rewarded for providing

essential safety-related information – but where there is also a clear line between acceptable and unacceptable behaviour.

- A *flexible culture* which can take different forms but is characterised as shifting from the conventional hierarchical mode to a flatter professional structure.
- A *learning culture* – the willingness and the competence to draw the right conclusions from its safety information system, and the will to implement major reforms when the need is indicated.
- A *wary culture* – where everyone is always alert to expect the unexpected, questioning is common and there is a desire to continuously improve as demonstrated by activities such as benchmarking.

The above points describe an image of the way of life culture. As previously mentioned this step is not difficult but may involve evolution of the management system extensively as it moves towards full integration with the processes and activities that occur across the site.

The next section of the guideline presents in some detail an image of a fully integrated risk management system called the Minerals Industry-Integrated Risk Management (MI-IRM) Model. The MI-IRM Model was developed in 1999 and 2000 to help describe integrated risk management to mining engineers in under-graduate and post-graduate courses.

In the MI-IRM Model, and at the Resilient rung, risk assessment is almost transparent in the defined management and engineering processes for the site. For example, mine planning includes steps related to risk assessment as a part of the defined mine planning process. Purchasing requires risk assessment as a step, based on defined risk criteria, within the purchasing process. The location of risk assessment applied with the appropriate methods and resources within key business processes achieves the objective of integration.

Unlike risk assessment, investigation remains a separate activity though it is likely that investigation at the “Resilient” rung will involve highly participative systems’ focussed review for any deviation that could cause or has caused significant losses to the business. As such investigation becomes a learning mechanism connected to communication, competency and leadership.

At the Resilient rung mechanisms of checking would be focussed on priorities that were evident to all concerned. Checking would be an accepted part of the “way we do business”, integrated into the same processes where risk assessment might be considered such as mine planning, purchasing, maintenance planning, procedure development and application, competency development etc. It would also be likely that a site at the “Resilient” rung would invite third party external review of their system as an attempt to continually improve and benchmark against others.

The achievement of the Resilient rung can also be described as indicating a “self-regulating” style. This is not to say that acts and regulations would not be required. Rather that the site risk management system and the “way of

life" culture far exceed any requirement that can be defined through regulations providing the optimal safe and productive outcome.

In summary the last step on the ladder from "Proactive" to "Resilient" involves the following changes:

- **Moving from an ownership to a way of life culture by tuning the risk management system based on the input of everyone**
- **Having totally open communication approaches established with the recognition that an informed learning and reporting culture is part of the resilient organisation**
- **Evolving fully integrated risk management systems developed by the management, engineer and supervisor owners based on their appreciation of the value**
- **Having risk assessment integrated into key systems achieved by using risk assessment methods to develop key systems and processes such as mine planning and maintenance, as well as defining risk assessment within appropriate systems and processes**
- **Realising a total focus on eliminating problems before they occur as illustrated by leadership, vision and mechanisms that communicate the unacceptability of incidents and accidents as well as an open and honest environment where communication of issues is natural at all levels**
- **Using 3rd party auditing by commissioning external experts to check and also challenge that the accepted well-defined risk management system is not only in place but also in need of continuous improvement**

3.6 Key points from this Chapter

This Chapter has attempted to walk the reader through a "rung by rung" journey up the MIRM ladder to a resilient, integrated risk management system that is accepted and supported by a culture that is "the way we do business". Each of sub-sections 3.2, 3.3, 3.4 and 3.5 attempts to provide a brief image of actions or at least directions that should be taken by a site to move from where they are to the next rung.

The MIRM ladder is not a guideline but rather a description of a journey that is intended to fit any minerals industry site. It has been provided to assist sites with identifying their current status on the journey and potential next steps for improvement.

The most important two points that the MIRM ladder attempts to address are as follows:

- The ladder suggests five steps in the journey to a resilient management system. It is important to recognise that skipping a step or rung in the ladder is difficult. It is likely that a site will spend some time, perhaps years, successfully progressing from one rung to the next.

- The MIRM and Hudson Ladders both suggest a strong relationship between the people factor or culture of the site and the status of the systems at the site. It is critical to recognise that systems cannot progress up the ladder without culture progressing in parallel.

Chapter 4 A Model of Integrated Risk Management

The Minerals Industry-Integrated Risk Management (MI-IRM) Model is intended to illustrate a fully integrated risk management system, part of the top or Resilient rung on the ladder model provided in the previous Chapter. The model has been defined to supply an image not a specific expectation. Companies and sites might use this model to help progress their own systems.

It is important to note that implementing an approach similar to this model may be premature for many mine sites. See the previous Chapter to identify the level of site maturity.

Minerals Industry-Integrated Risk Management
Major Five Areas

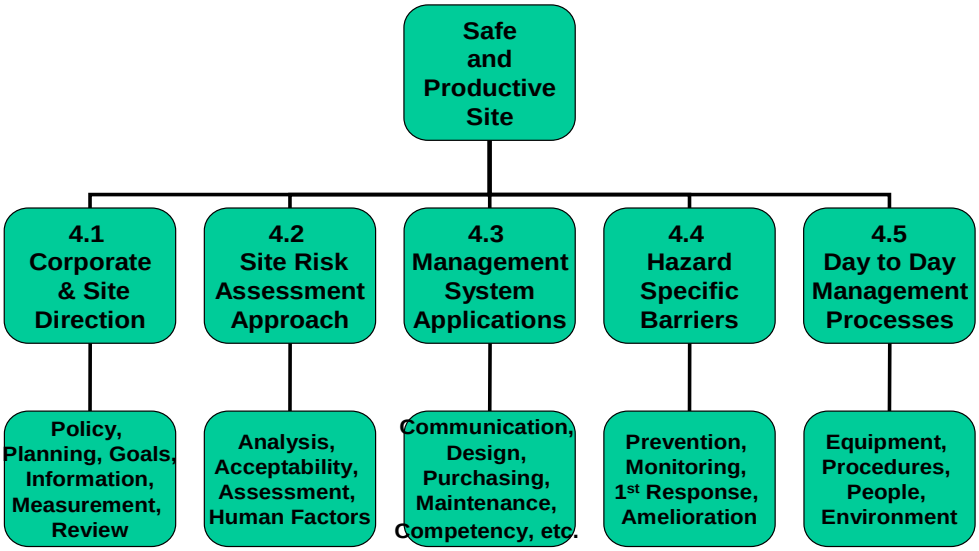


Diagram 4A – Minerals Industry–Integrated Risk Management Major Five Areas

The MI-IRM model was developed based on the principle that integrated risk management involves making important decisions throughout the business, systematically considering risk in the process. The five areas of the model suggest that several parts of the site management system must include careful integration of risk to optimise the quality of engineering, management and workforce decisions.

Safe and Productive Site

The top box of the model is, of course, the intent of the subsequent five sub-components. The ingredients of an effective integrated risk management system should lead to Safe Production, not production without safety or safety without production.

Safe Production should be the goal of the minerals industry where “safe” refers to the protection of people, assets, the environment, the community and other stakeholder’s interests. Specifically, this means that that target is production with minimal losses.

To achieve Safe Production there must be a quality decision making process for critical functions that, at the appropriate point for the function/role, considers the potential negative scenarios or outcomes in deriving the appropriate action.

Source: Rio Tinto Coal Australia

The identification of key engineering and management decisions where significant unwanted and/or unnecessary risks can be assumed is key to effective risk management. It is important to recognise the need to identify the critical decision points and, by careful analysis, deduce the best approach to Safe Production.

It is also important to note that a quality decision making process will only produce the desired output if the organisational culture supports that process through features such as:

- Provision of competent persons for the process
- Availability of time and other resources to undertake the process
- Support for the decision making process so it occurs when expected
- And, reinforcement for the process through recognition of its importance, as well as effective execution of the decision outcomes

The degree to which the organisations’ culture supports proactive decision making to reduce key risks should be seen as an indicator of a resilient organisation.

4.1 Corporate and Site Direction

Minerals Industry-Integrated Risk Management
Area 1: Corporate and Site Direction

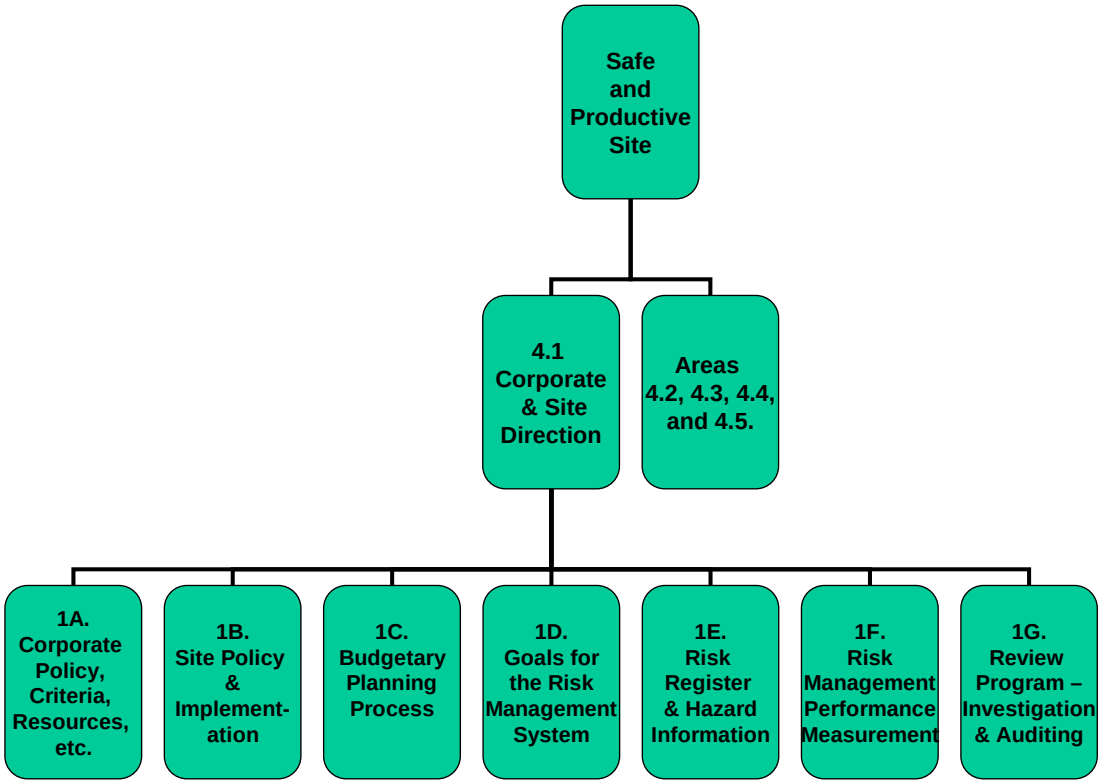


Diagram 4B – Minerals Industry-Integrated Risk Management Area 1: Corporate and Site Direction

The Corporate and Site Direction component of integrated risk management sets the vision and the management systems for the entire approach.

4.1.1. Corporate Policy, Criteria, Resources and Communication

The clear and demonstrated commitment of the corporate entity, which provides direction and resources to the site, is a key component of an effective management system. Commitment includes the policy, criteria for site performance, leadership mechanisms and resources to execute required activities and clear communication from corporate to site concerning all aspects.

Commitment of corporate and site management to pro-active, systematic management of relevant risks is key to an effective risk management system. There should be criticality of overt commitment and the need to go beyond motherhood statements to give clear direction and support. The site should also have a Business Plan that indicates commitment through relevant goal statements, strategies, objectives, targets and resource commitments.

4.1.2. Site Policy & Implementation

Local commitment should follow the corporate direction. Site policy should not only be a statement of leadership and moral responsibility but also include words that provide each employee (general workforce, supervisors, engineers and managers) guidance on the importance of safety and health risk management in their roles.

Pro-active and effective risk management systems require clear direction, usually expressed in the form of an OH&S and/or Risk Management Policy. The Policy should include or be supported by criteria for application, criteria for risk management (including acceptability of risk) and mechanisms to communicate the Policy and criteria to the relevant personnel.

4.1.3. Budgetary Planning Process

A site that has successfully integrated risk management into its processes would also have a systematic approach to budget and strategic planning that included funding activities or changes required to reduce risk. These priority changes may have been identified in a risk assessment, investigation, audit or some other risk management activity. Tracking the relevant suggested new barriers will likely be done through a site risk register (see 4.1.5.)

4.1.4. Goals for the Risk Management System

In addition to the Policy, the site should establish specific goals for the risk management system in order to direct and focus activities and outcomes. These goals should be a part of the annual planning process. Goals related to safety and health are critical. It may also be desirable to set goals related to asset, production/schedule and environment protection in the same risk management approach. These goals should be incorporated into business plans and the plan should include information derived with the intent of meeting the goals.

4.1.5. Risk Register and Technical Hazard Information

A site risk register should be developed and updated to establish a single source of all risk related information. Risk registers are common at mine sites today. They usually provide a columnar layout of risk information derived from risk assessments done across the site. Detailed design of a risk register varies but requirements for risk registers are included in ISO 14000 and 9000 standards.

Behind the risk register a site should have the appropriate information on the nature and magnitude of relevant hazards. There should also be information that explains the possible negative consequences related to that hazard. For example, a Material Safety Data Sheet (MSDS) should exist for all chemicals on site. For hazards related to roof fall in an underground mine the site should have a written document that defines the magnitude of roof/rib or back/sides

hazards and supplies valid information and assumptions that can be used to make relevant decisions at all levels.

Source: Port Waratah Coal Services

The recognised importance of investigating and understanding any hazard (something with the potential for harm) should be part of the culture. The site should link this information to the relevant processes and tasks, ensuring that personnel have the technical information required to understand the hazard and its potential consequences.

4.1.6 Risk Management Performance Measurement

The adage “what gets measured gets done” is often used in management training to illustrate that measurement drives the performance of people. Those people can be engineers, managers, workforce personnel or anyone else.

Effective safety and health risk management requires selection of performance measures that are measurable and meaningful. Traditional measures such as Lost Time Injury Frequency Rate (LTIFR) have limited value since they are outcome measures indicating more than good safety and health. Low LTIFR can also indicate aggressive claims management methods.

Measures of losses that track severity or costs are better than frequency alone. Measures that involve the quality of the process are also desirable. The

challenge is to identify day-to-day process measures that accurately indicate successful risk management, as well as being easy to track.

There should be a documented set of performance measures with targets, as well as a clear and effective method of gathering, analysing and reporting performance information.

4.1.7 Review Program – Investigation and Auditing

Performance Measurement, as well as Monitoring, are ongoing activities that check and track adherence to standards and targets. Review activities occur occasionally, sometimes based on a schedule. They also check on adherence. Incident/Accident Investigation and Auditing are two major forms of review. Both require a systematic, documented procedure.

The company or site should have information that clearly makes a commitment to learning from unwanted events, ideally not only events that cause serious losses but also events that could have led to major losses but did not.

Any minerals site must have a documented procedure for investigating unwanted events. Unwanted events can occur in any part of the site, delivering different outcomes. The site Incident/Accident Investigation Process should be scaled to apply the appropriate level of investigation to an unwanted event. The scale of investigation may vary from brief consideration to lengthy detailed team investigation.

Ideally, the site should set the investigation criteria based on potential outcomes rather than actual outcomes. This ensures that the site investigates the most significant issues.

There are several analytical tools that assist in the investigation of serious potential or actual events. The following set of tools is provided in System Safety Accident Investigation [see http://www.eh.doe.gov/csa/aip/workbook/]

- Events and Conditions Charting
- Energy Barrier Tracing
- Human Error Analysis
- Fault Tree Analysis
- Gap Analysis for Codes, Standards and Regulations
- Gap Analysis for Management Systems

These tools, and other similar approaches such as Tap Root and ICAM, provide a framework for team-based event analysis. An effective Incident/Accident Investigation Process should include a requirement for team-based analysis of major events.

There should be a documented Incident/Accident Investigation Process that includes defined levels of investigation, specific to an actual or potential outcome. Major investigations should consider the expectations developed by

relevant risk assessments to determine if the risk management system is working effectively. The process should include derivation of actions to improve after the event, as well as feedback to the workforce and follow up review to ensure actions are implemented.

Regular, systematic **auditing** of the risk management system is an essential part of the model. The site must have a process that compares the actual situation to the expected as defined in management system procedures and plans. Auditing should include review of documentation, as well as observations of key performance areas.

Although the entire risk management system may not be audited in one effort, all aspects should be audited over a two or three year period.

There should be a documented auditing process that includes the areas to be audited, the schedule, the resources and the action planning/feedback approach to be followed with each audit.

Source: BHP Billiton Mitsubishi Alliance

4.2 Site Risk Assessment Approach

Minerals Industry-Integrated Risk Management **Area 2: Site Risk Assessment Approach**

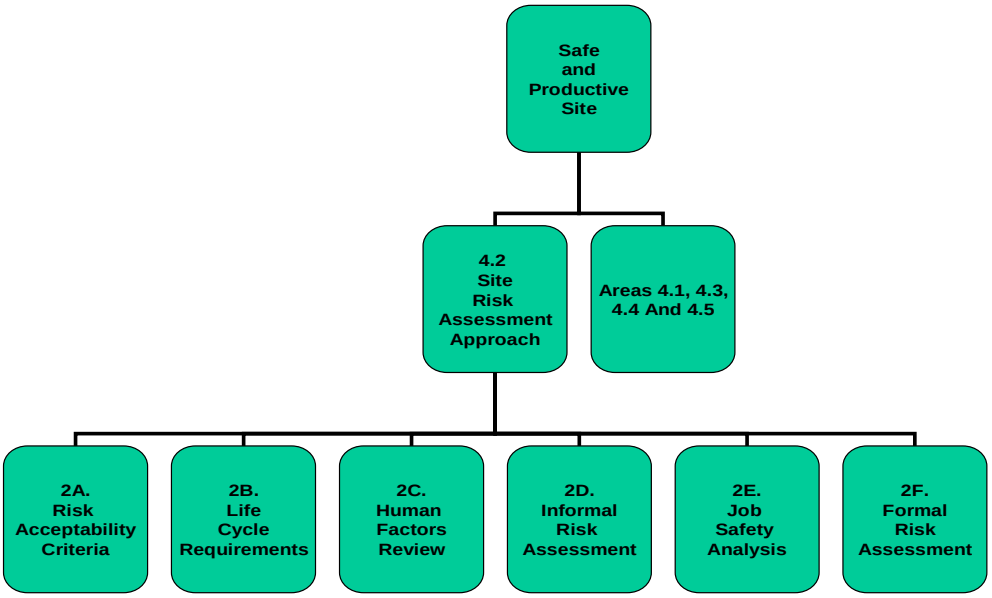


Diagram 4C – Minerals Industry-Integrated Risk Management Area 2: Site Risk Assessment Approach

Pro-active decision analysis is the key to effective risk management. As the term suggests, the risks in a decision must be considered before the risk is assumed rather than reactively.

A site that has fully integrated risk management will have a carefully designed set of expectations for risk assessment. The documented expectations would outline the principles and methods to be followed across the site, designed to suit the relevant decisions that are made by the site engineering, management, supervisory and individual workforce members. This information guides the site in the risk management process.

There should be a set of analytical tools for reviewing risks related to significant tasks. These tools should be clearly applicable to minerals industry requirements. The green boxes provide guidance on the topics that should be included.

4.2.1. Risk Acceptability Criteria

Regulatory approaches around Australia and the rest of the world use Duty of Care or similar approaches to suggest that the employer is responsible for managing risk to a level that is reasonably achievable (ALARA) or practicable (ALARP).

No Australian minerals industry regulatory authority (or, to the authors knowledge, any other country's regulatory authority) defines an objective figure for the level of occupational health and safety risk that is acceptable. The company and/or site should provide some practical guidance to engineers, managers and others on risk acceptability.

Messages such as “safety first” offer leadership, though to some degree this is impractical if interpreted to mean production will always be secondary to safety. This interpretation can lead to a “zero risk” mentality which is incorrect.

It may be more desirable to assign a method of calculating risk and define the level of risk where no new controls are required as a standard for the site.

4.2.2. Life Cycle Requirements

Life cycle of a site covers the project from concept phase through design and construction, and into operation, maintenance and modification. The life cycle is over when the project is decommissioned. All sites, equipment, materials, etc. have a life cycle.

Exactly the point where the pro-active methods should be applied is discussed in the next major area (4.3 Management Systems Applications). However, defined points in project life cycle where cost-effective risk assessment opportunities exist are desirable as a guide to the site.

The life cycle model of a project or process offers a framework for understanding roles. Design roles differ from construction roles. Operating differs from Maintenance and Modification. Understanding the life cycle concept helps to identify types of risks, as well as appropriate timing and methods for analysing risk.

4.2.3 Human Factors Review

Most unwanted events involve some form of human error, often for understandable and predictable reasons. The consideration of human fallibility in engineering and management decisions is critical, especially for areas where human performance is critical to success.

Several methods of reviewing potential for human performance issues exist which suit various situations.

Effective risk assessment, using the tools mentioned in 2.2 The Basic Risk Management Process, should help identify predictable human error. However, it is desirable to ensure that reasonable variations due to human fallibility are considered when personnel performance is critical. To ensure this analysis occurs it is desirable to have a “standard” procedure for Human Factors Review.

Engineers and managers should have a sound appreciation of the human factor in engineering. Legislation and other relevant mechanisms such as Australian Standards often suggest that designs must consider predictable human error.

The variations and fallibilities of normal human behaviour, as well as those of the anatomical, bio-mechanical and physiological aspects, need to be

understood, at least to the level where it is recognised that more information or expertise is required.

A Human Factors Analysis technique, which prompts the engineer to think about human issues in their work area, is critical to their skill base, as well as engineering ethics that support this approach.

4.2.4 Informal Risk Assessment

Every site should have a procedure and a process for informal risk assessment. Every person on the site should be skilled in identifying and addressing hazards involving unacceptable risks in their jobs.

A mental model should be introduced to all personnel such as the following:

- Pause before you start a task
- Look for hazards
- Consider the risks
- Act to reduce unacceptable risk (or do not proceed with the task)
- Report any unacceptable risk that needs further action

A process is also required in addition to the mental model which gathers requirements for further action, ensures required action is taken and feeds back action status to the initiator.

4.2.5 Job Safety Analysis

All operations should undertake the development of work procedures or instructions that set the standard for tasks, especially where the sequence of steps, the need for communication or the level of risk indicates that a step-by-step procedure is required. Note that guidelines for work, rather than a procedure, are often adequate when the previously mentioned criteria are not apparent.

Job Safety Analysis (JSA) offers the systematic, formal approach for development of procedures. A defined method for doing Job Safety Analysis should be in place, e.g. in the Documentation Process (see 4.3.5).

Engineers and managers are responsible for ensuring methods or guidelines are developed for doing the work. This information may be related to maintenance or production tasks. The term “Standard Operating Procedure” (SOP) is often used to describe the document that provides guidance for work tasks.

Job Safety Analysis should be recognised as the tool for building risk management into an SOP. A JSA Procedure should give clear guidance on the method of doing a JSA, including any forms.

4.2.6 Formal Risk Assessment

Formal risk assessment is a documented process, usually involving a team of relevant site and possibly off-site expertise.

There are many techniques such as the examples listed below:

HAZAN - Hazard Analysis
WRAC – Workplace Risk Assessment and Control
HAZOP – Hazard and Operability Studies
FMECA – Failure Modes and Effects Criticality Analysis
LTA – Logic Tree Analysis
FTA – Fault Tree Analysis
QRA – Quantitative Risk Assessment

Although very similar in principle, the above tools vary in detail to suit specific issues. It is important to note, however, a knowledgeable person can often tailor some tools for multiple applications. More information on risk assessment methods can be found in the NMISHRAG [www.mishc.uq.edu.au]

A minerals industry operation should use many of these tools to pro-actively reduce risks of major events or cumulative loss costs. Engineers and managers should have a tool box of analytical tools to help them systematically deduce and address risks in their various tasks. HAZAN (or WRAC), HAZOP, FMECA and FTA are the basic minimum set of risk engineering tools.

It is desirable to have all the site risk assessment principles and methods outlined in a standard document.

4.3 Management System Applications

Minerals Industry-Integrated Risk Management
Area 3: Management System Applications

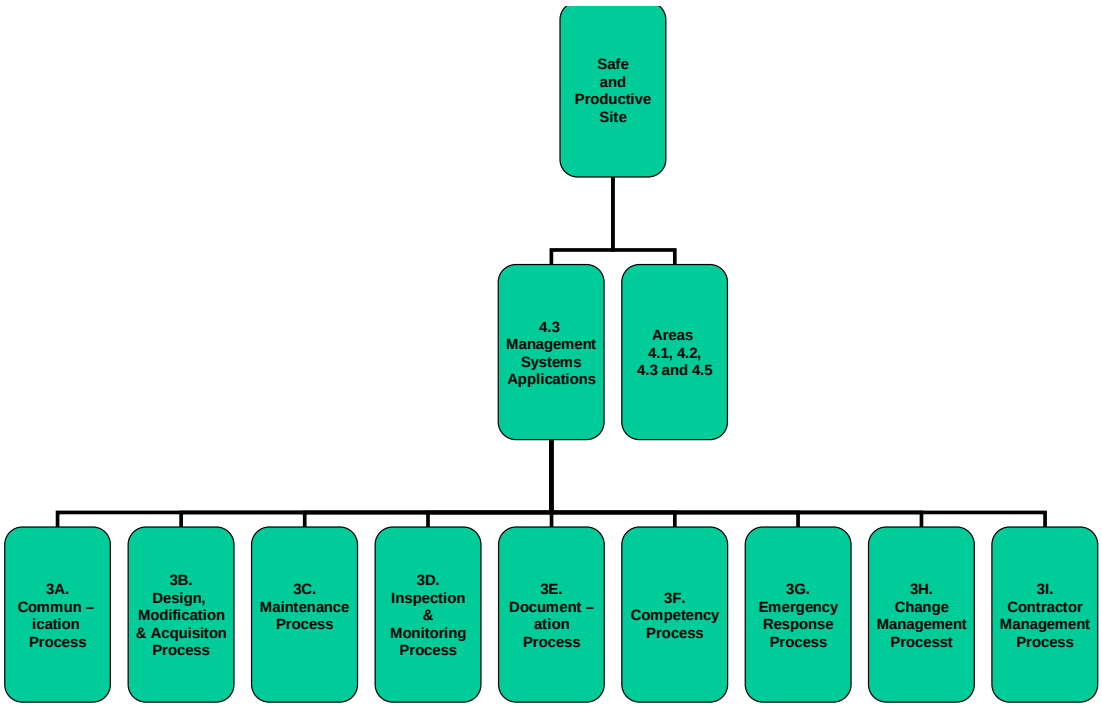


Diagram 4D – Minerals Industry-Integrated Risk Management Area 3: Management Systems Applications

There are many engineering and management processes that, with the appropriate approach, can greatly reduce risk in minerals industry operations. The management system components that design and operate a major site are quite extensive. Those listed in the chart above make up an example of a comprehensive approach relevant to a new project or operating site throughout the sites' life cycle.

There are a series of specific minerals industry engineering and management processes where decisions are made which affect the risk in the operation. When an unwanted incident occurs, investigations almost always identify problems in these areas. Sometimes these incident-related decisions are called "upstream" because they most often occur before the day of the event.

This area and its sub-areas define the specific engineering and management processes where guidance from Area 2. Site Risk Assessment Approach and its sub-areas should be applied.

The processes described in the following sub-areas involve decisions that affect the quality of equipment, materials, procedures, work environment, supervision and the person performing the work on the day.

The nine major minerals industry site processes include:

3A - Communication Process
3B - Design, Modification and Acquisition Process
3C - Maintenance Process

3D - Inspection & Monitoring Process
3E - Documentation Process
3F - Competency Process
3G - Emergency Response Process
3H - Change Management Process
3I - Contractor Management Process

These nine represent a list of the major minerals industry engineering and management processes where key risk decisions are made. However, the list is not intended to suggest that applying risk assessment to process design and operation is limited to these areas.

4.3.1. Communication Process

Good communication throughout the organisation results from the effective design and operation of a communication process. Like any process it must be designed to meet the needs of the organisation. Types of information, information objectives, sources, recipients, medium, timeliness, documentation control and other factors must be considered to design and operate a successful communication system.

The design of an effective communication process should consider the message, the media and timeliness. Risk management depends on effective communication to highlight hazards, update risk related information and gather input.

There should be a documented outline of the site communication process that addresses the site specific risk management needs. The outline should be reviewed using risk assessment. The document might include identification of various written and non-written methods to inform the various parts of the workforce about new or changing risks, as well as mechanisms to retrieve workplace input on hazards.

4.3.2 Design, Modification and Acquisition Process

Design, modification and acquisition are some of the most important and cost effective application areas for risk management. The opportunity to design in safety must be the priority when the consequences of design flaws, including error provoking designs, are major.

There should be a documented set of procedures dealing with the methods of designing and/or planning the site requirements. As previously mentioned, these procedures may not be located in the Risk Management Manual but rather in Engineering/Acquisition Procedures for the site. The procedures should include risk review where significant risks may be present.

Whether it is an exploration site, an operating mine or a process plant, design of the physical work environment is critical to success. A long history of events related to surface and underground mine design suggests that mine planning can be improved.

Source: Xstrata Copper

Tools for risk assessment should be selected from the Site Risk Assessment Approach and integrated into the **mine design/planning process** as the standard methodology. There should be a mine or site planning procedures that defines the method by which new plans or changes to plans are derived. Inherent in the procedure should be criteria for assessing risk based on potential hazards. The procedure should suggest one or more methods of assessing risk, as well as resource/expertise requirements and direction on application of results from the risk assessment.

The **design of new plant or modification of existing plant** for mining or processing also offers an opportunity to reduce the likelihood of losses due to plant that is not “fit-for-purpose”. Pro-active analysis of hazards and risks should be included in the plant design, acquisition and modification process, possibly including site safety and health criteria for specific hazards.

There should be plant design and modification procedures that define the method by which new designs or changes to plant are derived. Inherent in the procedure should be criteria for assessing risk based on potential hazards. The procedure should suggest one or more tools for assessing risk, as well as resource/expertise requirements and direction on use of results from the risk assessment.

Like plant, **equipment design or acquisition** should include formal consideration of hazards and risks. Most equipment will be purchased rather than designed by the site. Therefore the main focus with this process would be the acquisition or purchasing process.

The acquisition or purchasing process will usually require that significant purchases are done with a set of specifications. Safety and health requirements should be included in these specifications. It may also be

desirable to include a method of comparing risk issues when options are being considered.

The use of analytical tools to develop specifications or to compare equipment options also needs to be addressed. This would include risk assessment and human factors tools. There should be an acquisition procedure that defines the method by which purchasing is done. Inherent in the procedure there should be criteria for assessing risk based on potential hazards. The procedure should suggest one or more tools for assessing risk, as well as resource/expertise requirements and direction on use of results from the risk assessment.

Again, like plant and equipment, there should be pro-active analysis to acquire quality, safe **materials**.

Chemical safety can be greatly enhanced with careful acquisition of relevant production and maintenance materials, including review and use of Material Safety Data Sheets (MSDS). Engineers and managers should be familiar with the purpose and general content of MSDS information, as well as a reasonable understanding of chemical risk mechanisms (explosion, fire, contact, inhalation and ingestion).

This area may have already been identified and included in the acquisition procedure referred to earlier in this sub-area.

4.3.3. Maintenance Process

Development and application of maintenance plans, as well as selection of insurance spares and development of safe maintenance work practices, is a key part of any moderate to large minerals operation. Integration of safety and health risk management into the Maintenance Process involves considering the possibility of losses when making decisions in maintenance.

From the standpoint of asset and availability protection, techniques such as Reliability Centred Maintenance (RCM) are now becoming more common in the minerals industry. This method uses analytical methods to deduce high maintenance risks (low reliability, high consequence of failure) and, as a result, develop more effective maintenance plans. For safety and health, consequences to personnel could be added to asset damage or production delay in the RCM risk assessment.

The development of maintenance SOP documents with Job Safety Analysis (JSA) is also included in this process.

There should be a documented maintenance planning process that includes provision for considering risks to personnel, assets and production. As previously mentioned, the procedure may not be in the Risk Management Manual.

4.3.4. Inspection & Monitoring Process

Inspection is a regular activity that checks the status of specific items in the work place. Equipment is inspected before each shift as well as less frequently in more detail for maintenance purposes.

Monitoring is an ongoing process of checking the status by observation or by gathering information with equipment. Supervisors monitor adherence to work practices. Gas monitors identify the level of specific hazardous gases in certain locations. The exact hazard monitoring requirements should be determined by defining the monitoring barriers required for the relevant hazards (see 4.4.2. Monitoring Barriers).

Inspection and monitoring processes should be derived by consideration of the relevant risks where monitoring is key.

There should be defined Inspection and Monitoring Procedures, focusing on priority site risks. Inspection procedures that target critical plant or equipment should exist. Monitoring of behaviour may be targeted through selection of major suspected sources of human error. Monitoring of hazards should be especially targeted on major hazards where status monitoring is key to management.

4.3.5. Documentation Process

The documentation of standards for the various work methods and processes on the site is critical for the development of a management system. The identification of required detailed documentation, such as SOPs, should be done using criteria where:

- Methods require a clear, step-by-step process
- Risks in the method are significant if not done correctly
- Coordination is critical for complex methods
- There is general recognition that documentation would be helpful

It should also be noted that documentation applies to management and engineering processes, as well as operating or maintenance tasks.

Document control, as suggested in Quality Standards, should also be used. Ideally, the site should have a documented process for developing documentation that includes criteria for required documentation, method of deriving documented standards, methods for introducing new documents and methods for monitoring and reviewing documentation.

The site should use proactive, systematic methods for document development considering tools such as Job Safety Analysis (JSA). JSA is commonly used for drafting one type of work site documentation, a Standard Operating Procedure (SOP).

Finally, the site documentation process must include documentation of engineering and management processes, such as the nine that are mentioned

in this area, that involve decisions where significant risks can be inadvertently assumed. These documents should include requirements for pro-active analysis to consider risks.

4.3.6. Competency Process

A competent person is an adequately qualified, effective, adequate, legitimate person, according to the dictionary. For this model, a competent person is one who has sufficient knowledge and skills to perform the required task safely and productively.

The development of competency is a process. A site should have a process that includes selection, induction and training in the site-specific requirements to ensure adequate competency.

The first step involves identifying competency requirements, especially those that are different from or in addition to existing ticketed or licensed competencies, such as electricians, fitters, engineers, mining officials, etc.

Once a need is identified, objectives should be defined, resources to improve competency developed and some form of training delivered. As in other processes the outcome should be monitored to ensure the process is effective. In other words there should be monitoring to identify the degree to which training is effective.

Without required documented risk assessed standards and a relevant competency development process, the work-site relies on the individual's perception of the task requirements and past learning.

There should be a documented competency approach that clearly identifies competency requirements for the site and the process by which this is managed.

As part of the competency process, the site should have a systematic selection process. Effective selection involves identifying the knowledge, skills and other requirements of the site. Searching for potential selection candidates should be done with clear requirements. Final selection should involve careful consideration versus requirements, as well as verification of capability through quality references.

It is important to note that some parts of the minerals industry still apply a selection process that is limited by industrial agreements.

The site should have a documented training program that includes competency objectives, training content, assessment methods and records of training. The site should have an up-to-date record for every employee, including induction information and requirements for re-training/refreshers.

There should be training materials and a record system. The goal would be information covering all significant tasks and processes.

4.3.7. Emergency Response Process

Any minerals site must have an Emergency Response Plan (ERP) that has been systematically developed to address the possible major events. Identification of the events that require inclusion in the ERP can be done using risk assessment. The ERP should include clear direction on actions to be taken from discovery of major events such as fires, through to evacuation/egress and off site support such as Mines Rescue, fire and ambulance services. Capability of local medical services to assist with injuries typical of the site hazards should also be included.

The ERP should give clear, effective direction to those persons which can be affected by the event and those who must take action should the event occur. ERP content should be included in induction and other training. It should also be available for reference where required.

4.3.8. Change Management Process

The introduction of changes to operating practice, rules, procedures, hardware or support systems introduces the possibility of unwanted outcomes where people's decisions are based on out of date or incorrectly interpreted knowledge. Unsanctioned changes can introduce unexpected and unwanted outcomes sometimes with catastrophic outcomes.

In addition, operating environments change due to natural forces e.g. rain, lightning, ground movements etc.

A management system should be in place to ensure that changes have been subject to risk assessment prior to implementation and that significant changes are communicated to those persons who should factor the differences into their decisions.

There should be procedures adopted when change is being considered or implemented. The procedure should clearly identify when it can be by-passed. It should detail who is authorised to sign-off on the risk management steps that must be included before modification sign-off will be granted.

4.3.9. Contractor Management Process

Risk transfer from the principal to a contractor requires risk sensitive processes. Legislated constraints prevent transfer for issues such as Occupational Safety and Health and environmental pollution.

Communications between contractor's personnel and the principal's officers needs to be carefully established to avoid unwanted outcomes due to distortion or loss of communications.

The contractor's ability to identify the possibility of unacceptable outcomes of their work should be clearly understood. Where they lack the resources or

skills to provide an adequate set of defensive barriers then the principal should ensure that such defences are provided.

The contract covering the work to be done on a site should detail the risk management process that the contractor will implement. The contractor's proposals should identify the points at which the principal shall be required to sign-off and thereby assume responsibility for the risk identified.

There should be contract requirements for the supplier/service provider to carry out risk assessment and implement the necessary defensive barriers against unwanted outcomes. Critical check points for the principal should also be evident and they should address all critical outcomes.

4.4 Hazard Specific Barriers

Barriers are the equipment, materials, rules, methods, competencies, labels or other mechanisms that are put in place to control a hazard. A hazard is something with the potential to do harm. Safety and health losses occur because barriers related to hazards are less than adequate.

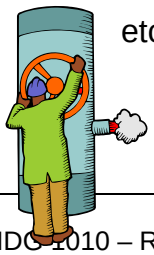
The Energy Concept is useful for understanding safety and health hazards. Physical damage to people can only occur due to some form of energy. There are nine common energy sources.

1. Gravity – falls of things, falls of people, uncontrolled movement (minerals hazards such as fall of ground, falling off structure, vehicle runaways, etc.)

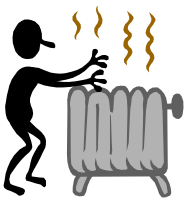
2. Chemical – solids, liquids, gases that burn, explode, affect people due to contact, inhalation or ingestion (minerals hazards such as spontaneous combustion in coal, sulphide dust explosion, methane explosion, acid spills, fuel/oil fires, etc.)

3. Electrical – contact, induction, arcing (minerals hazards such as inadvertent contact, faults, arcing in a gaseous environment)

4. Mechanical – caught in, hit by, collisions (minerals hazards such as vehicle collisions, caught in moving equipment, hit by moving machinery, machine vibration, etc.)



5. Pressure – release or explosion of air, water, hydraulics or mechanical items under pressure (including noise) (minerals hazards such as pneumatic/tyre failures, hydraulic pressure releases, spring pressure release, excessive noise, etc.)



6. Radiant – radiation, hot or cold surfaces (minerals hazards such as radioactive materials, sunshine, overheated mechanical equipment, refrigeration systems, etc.)

7. Magnetic – items that are magnetised (minerals hazards such as magnetism used in aluminium processing, etc.)

8. Bio-mechanical – the body's mechanical energy that slips, trips, strains, sprains (minerals hazards such as manual handling, poor housekeeping, poor access, poor work positions, etc.)

9. Microbiological – viruses, bacteria (minerals hazards such as hepatitis, tinea, sewage effluent, aids, etc.)

Effective barriers are deduced by identifying the energies that are present on the site as well as establishing their location, exact nature and magnitude. Once this information is understood risks can be assessed and barriers defined to suit the risk.

Barrier definition should consider a four-stage approach:

1. Prevention – barriers intended to prevent the energy from getting out of control
2. Monitoring – barriers intended to monitor the status of the energy to identify if it is different from expected
3. 1st Response – barriers intended to stop an unwanted event in the early stages before any significant consequence can occur
4. Amelioration – barriers intended to minimise the consequences of a major unwanted event (Emergency Response plus other activities)

The four stages are also in the order that should be used to deduce Barriers. Prevention should always be the first concern. Monitoring is also important and, in some cases, an under-utilised approach in the minerals industry.

Management System Applications usually identify, develop and put in place the Hazard Specific Barriers. Hazard Specific Barriers are selected by the Management System Applications. Therefore if good approaches to risk assessment have been applied in the various aspects of Management Systems Applications, derived from the methodology in the Site Risk Assessment Approach (section 2. of this model), then the appropriate Hazard Specific Barriers should be available.

4.4.1. Prevention Barriers

Prevention Barriers are intended to prevent a loss or unwanted energy release. They can involve many different approaches. The following **Hierarchy of Control**, adopted in many regulatory approaches, offers a good framework for deducing the optimal Prevention Barriers. Note that the effectiveness of a barrier that is intended to reduce a risk decreases from top to bottom of the list. In other words, the closer the barrier type is to the top of the hierarchy, the more potentially effective the control.

1. Eliminate the hazard or energy source (do not use the energy)
2. Minimise or replace the hazard or energy source (reduce the amount of energy to a less damaging level or replace the energy with another that has less potential negative consequences)
3. Control the hazard or energy using engineered devices (e.g. lock outs, chemical containers, mechanical roof support, gas monitors, etc.)
4. Control the hazard or energy by using physical barriers (e.g. machine guarding, warning signs, etc.)
5. Control the hazard or energy with procedures (e.g. isolation procedures, standard operating procedures, etc.)
6. Control the hazard or energy with personal protective equipment (e.g. hard hats, boots with toe caps, gloves, safety glasses, welding gear, etc.)
7. Control the hazard or energy with warnings and awareness (e.g. posters, labels, stickers, verbal warnings, etc.)

Every unacceptable inherent or uncontrolled risk at the site should have defined Prevention Barriers. The above Hierarchy of Control is useful to determine the optimal Barrier.

4.4.2. Monitoring Barriers

Monitoring Barriers are intended to check the status of a hazard or energy to identify any variation or change that may indicate that the hazard is no longer under appropriate control.

Two basic types of monitoring are used as barriers; **process monitoring** and **outcome monitoring**. Process monitoring checks the status of the expected Prevention Barriers as an indicator of potential problems. For example, monitoring the condition of machine guarding or monitoring the execution of isolation procedures may indicate adherence problems for important Prevention Barriers. Monitoring the roof support methods may indicate problems that could lead to fall of ground.

Absent or weak Prevention Barriers indicate that the risk has changed. If the risk was seen to be acceptable with the expected controls and they are found to be absent or weak, the risk may now be unacceptable.

Outcome monitoring checks the results of the process, or the status of the hazard itself, to indicate whether the Prevention Barriers are working and/or if the hazard is different from expected. Gas monitoring, either manual or automatic, is one example. Two other examples are tell-tales on roof support and vehicle systems that gather speed and/or load data.

Well-designed automatic monitoring is more reliable than manual monitoring. In general, process monitoring often gives earlier warnings of failed Prevention Barriers than outcome monitoring.

Source: Rio Tinto Coal Australia

4.4.3. First Response Barriers

First Response Barriers are intended to identify and address an unwanted event in very early stages. Often these Barriers involve automatic detection and action. For example, a sprinkler, foam or dust system, triggered by heat or smoke, is intended to extinguish a heat source or fire in its early stages. Gas monitors that detect predetermined explosive gas levels and shut down heat sources are also First Response barriers.

There are also manual First Response barriers such as the combination of fire training and the local availability of portable fire fighting equipment. Procedures and expertise to re-secure bad roof, and eye washes or acid neutralisers in minerals laboratories are also First Response.

The main issues with First Response Barriers are a clear, relevant definition of the event that triggers the response and the availability of the barrier when and where the unwanted event occurs.

Some parts of the Australian mining industry use the term TARPS (Trigger Action Response Points) to describe the defined point where a hazard or condition initiates action. Examples include carbon monoxide gas levels in an underground coal mine as an indicator of a fire or spontaneous combustion.

Since trigger levels are designed to indicate the possibility but not the absolute certainty of a major unwanted event, some automatic First Response Barriers may trigger spuriously, seemingly unnecessarily at a hazard level that has a high safety factor (1.25% CH4 when 5 to 15% is explosive). This may lead to compromising the Barriers by deliberate shutdown or some other form of action.

4.4.4. Amelioration Barriers

Amelioration Barriers are intended to minimise the consequence of a major event by removing the people from the event and minimising damage to people through appropriate response, rescue, treatment and other activities.

Aspects of Amelioration include the following.

- Barriers that protect the person or asset from damage once the event occurs (seat belts, eye protection, steel toed boots, escape routes, etc.)
- Prevention of a second accident
- Emergency action and rescue
- Medical services, including first aid, transport, personnel and equipment
- Rehabilitation and business recovery
- Relations with employees, officials, public and the media

Like the other barriers, they should be tailored to suit the risks, in this case the major event outcomes of those risks. The site Emergency Response Plan should document the sum of all Amelioration requirements (see 3G. Emergency Response Process).

4.5 Day to Day Management Processes

Minerals Industry-Integrated Risk Management **Area 5: Day to Day Management Processes**

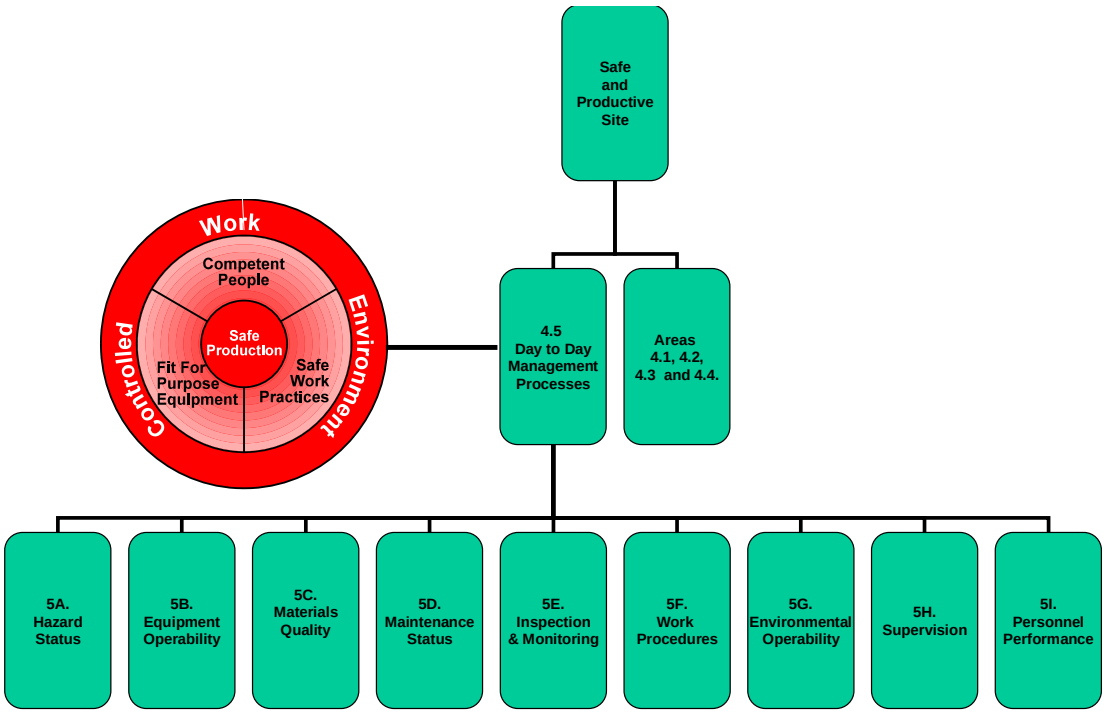


Diagram 4E – Minerals Industry-Integrated Risk Management Area 5: Day to Day Management Processes

Day to Day Management Processes is the final area of the Minerals Industry Risk Management Model. This area applies to decisions made immediately before or during a task.

The chart above shows a wheel illustrated as an attachment to this area. This Work Process model (or Nertney Wheel) has been borrowed from System Safety information developed by the U.S. Department of Energy for use in the nuclear power industry.

The Nertney Wheel suggests that Safe Production is achieved by having four key ingredients in any task, outlined more thoroughly in Chapter 2.2.

- Fit for purpose equipment and materials
- Quality work methods (safe work practices)
- Competent people, and
- A controlled work environment (both physically and from a supervision standpoint)

Diagram 4F – Nertney Wheel

The design of the Nertney Wheel illustrates that the four ingredients have an inter-dependent relationship. The design or condition of each will impact on the other three. All four aspects of the Nertney Wheel work process model must be satisfactory to get the desired outcome; the circle in the middle, Safe Production.

Day to Day Management Processes are the ongoing mechanisms that are used to ensure that the Work Process is in place and operating to the expected standard. In this Mineral Industry – Integrated Risk Management model there a nine major topics, listed below, that are intended to represent the Key Control Areas for the Work Process:

- Hazards Status
- Equipment Operability
- Materials Quality
- Maintenance Status
- Inspection and Monitoring
- Work Procedures
- Environmental Operability
- Supervision
- Personnel Performance

There is a close relationship between the actions that occur in Day to Day Management and the outputs of the Management Systems Applications (Diagram 4A Section 4.3). Management System Applications usually identify, develop and put in place the Day to Day Management Processes. The Work Process is designed by the Management System Applications. Therefore if good approaches to risk assessment have been applied in the various aspects of Management Systems Applications, derived from the methodology in the Structured Risk Assessment Approach (Diagram 4A Section 4.2), then the Work Process will have an optimal design. However, failures can occur because the Work Process does not always occur as the Management System expected or intended.

To manage the risk that could not be designed out of the work process the Day to Day nine areas listed above should be effective for all tasks at all times. This area of risk management is where the proverbial rubber meets the road.

4.5.1. Hazard Status

The workforce must be aware of the existence and status of any relevant hazard he or she may be exposed to in the undertaking of their work.

The Risk Register and Hazard Information element of this model (see Diagram 4B) notes the requirement for the site to be aware of relevant hazards and have available information that describes the hazard and its status, possibly assembled into one information document called a Risk Register.

Communication Process (Diagram 3A) should ensure that the relevant people are aware of any changes to the hazard that may affect the risk.

Competency Process (Diagram 4D) describes the need to have a systematic approach to developing competency, including knowledge and skills related to relevant site hazards, thereby ensuring that the individual knows how to control a hazard.

Under Hazard Specific Barriers, Monitoring (Diagram 4A) involves having methods to check the status of hazards to ensure they are at expected levels.

Informal Risk Assessment (Diagram 4C) defines the requirements for a process of identifying hazards and acting to reduce the risk in a task to an acceptable level.

These five elements should combine to ensure that, on the day, there is a clear awareness of the existence and magnitude of a hazard.

This element of the model, Hazards Status, suggests that all persons involved in the specific work process (or task) should be aware of any hazards. Each individual should be told about any new information concerning hazards. In addition, he/she should apply Informal Risk Assessment or Hazard Identification methods on the day as the last step in identifying unacceptable risks and thereby avoiding losses.

4.5.2 Equipment Operability

The Management Systems Application titled Design, Modification and Acquisition Process (Diagram 4D) notes the requirement for a process of considering hazards in the design, modification and acquisition of plant and equipment.

Various methods of deducing risks related to equipment or plant are defined in Formal Risk Assessment (Diagram 4C) and Human Factors Review (Diagram 4C).

Under Hazard Specific Barriers (Diagram 4A) the specific plant or equipment requirements for preventing unwanted events, monitoring hazards or responding to unwanted events are defined.

These three elements should ensure that, on the day, the plant or equipment required for the task is “fit-for-purpose”, capable of the work required and designed to minimise relevant risks.

The Communication Process (Diagram 4D) should ensure that the relevant people are aware of any changes to the plant or equipment that may affect the risk.

The Competency Process (Diagram 4D) describes the need to have a systematic approach to developing competency, including knowledge and skills related to relevant site hazards, thereby ensuring that individuals know how to operate the plant or equipment.

This element of the model, Equipment Operability, suggests that the assigned equipment on the day must be fit-for-purpose. Within the work process there must be work organisation and scheduling that ensures that the right plant and equipment are available for the task.

4.5.3. Materials Quality

The Management Systems Application titled Design, Modification and Acquisition Process (Diagram 4D) also notes the requirement for a process of considering hazards in the acquisition of materials.

Various methods of deducing risks related to materials, especially hazardous chemicals, are defined in “Formal Risk Assessment” (Diagram 4C) and Human Factors Review (Diagram 4C).

Under Hazard Specific Barriers (Diagram 4A) the specific materials requirements for preventing unwanted events, monitoring hazards or responding to unwanted events are defined.

These three elements should ensure that, on the day, the materials required for the task is fit-for-purpose.

The Communication Process (Diagram 4D) should ensure that the relevant people are aware of any changes to the materials that may affect the risk.

The Competency Process (Diagram 4D) ensures that the individual knows how to use the materials. Knowledge of Material Safety Data Sheet (MSDS) information is included in this process.

This element of the model, materials quality, suggests that the supplied materials on the day must be fit-for-purpose. Within the Work Process supplies must be organised to ensure that the right materials are available for the task.

4.5.4. Maintenance Status

The Management System Process titled Maintenance Process (3C in the model) notes the requirement for a process of systematically planning maintenance, including insurance spares and maintenance Standard Operating Procedures (SOP).

Various methods of deducing risks related to maintenance are defined in Formal Risk Assessment (Diagram 4C) and Job Safety Analysis (Diagram 4C).

These two Management elements should ensure that, on the day, the plant or equipment required for the task is adequately maintained so that it is fit-for-purpose.

This element of the model, Maintenance Status, suggests that the assigned plant or equipment, on the day, must be maintained to the required standard, as determined by the Maintenance Plan.

4.5.5. Inspection and Monitoring

The Management System Process titled Inspection/Monitoring Process notes the requirement for the site to have a systematically derived process of inspecting and monitoring key plant, equipment and activities to ensure that performance is as expected.

Under Hazard Specific Barriers, Monitoring (Diagram 4A) involves having methods to check the status of hazards and barriers to ensure they are as expected.

These two elements should ensure that, on the day, there is a clear image of the inspection and monitoring requirements.

The Competency Process (Diagram 4D) describes the need to have a systematic approach to developing competency, including knowledge and skills related to inspecting or monitoring.

Management, engineering and supervisory personnel may be involved in the design and implementation described in inspection and monitoring process (Diagram 4D). However, this day to day activity, inspection and monitoring, suggests that these persons must also undertake, among other things, the role of observer, informally inspecting and monitoring the work site.

A key control in the day-to-day work process involves supervisory initiative to stop or delay the work and address a lack of adherence to standards, whether it is deliberate or unintentional. Failure to do so condones bad practices.

4.5.6. Work Procedures

The Management System Process titled Documentation Process (Diagram 4D) notes the requirement for the site to have a systematical process of developing required Standard Operating Procedures (SOP) for the site. The use of Job Safety Analysis (Diagram 4C) is also suggested to integrate risk reduction requirements into the SOP.

Under Hazard Specific Barriers (Diagram 4A) the specific procedures for preventing unwanted events, monitoring hazards or responding to unwanted events are defined.

The Competency Process (Diagram 4D) describes the need to have a systematic approach to developing competency, based on the relevant work procedures.

The Communication Process (Diagram 4D) should ensure that the relevant people are aware of any changes to the required procedures that may affect the risk.

These four elements should ensure that, on the day, there is a clear image of the safe, correct method for the task.

This element of the model, Work Procedures, suggests that the appropriate work method on the day must be adequate to control the risks. Within the work process there must be short term work planning and organisation that ensures the correct Work Procedure can be determined. In the minerals industry, rapidly changing and complex work environments often require modification of an existing SOP or determination of a new unique work method. There must be mechanisms to ensure quality short term work planning is done.

4.5.7. Environment Operability

The Management System Process titled Design, Modification and Acquisition Process (Diagram 4D), specifically the content related to mine or site planning, notes the requirement for a process of considering hazards in mine design, including aspects such as ventilation, lighting, transport needs, services, etc. This process should produce a safe and good quality work environment.

Various methods of deducing risks related to the mine or site environment are defined in Formal Risk Assessment (Diagram 4C).

Under Hazard Specific Barriers (Diagram 4A) the specific environmental requirements for preventing unwanted events, monitoring hazards or responding to unwanted events are defined.

These three elements should ensure that, on the day, the work environment for the task is adequate and free from unacceptable risks.

The Communication Process (Diagram 4D) should ensure that the relevant people are aware of any changes to the work environment that may affect the risk.

This element of the model, Environment Operability, suggests that the work environment on the day must be adequate for planned operations, ensuring that there are no unacceptable related risks. In the minerals industry, rapidly changing conditions often reduce the quality of work environments. There must be mechanisms to ensure quality short term planning considers the work environment and addresses the issues.

4.5.8. Supervision

The Management System Process titled Competency Process (Diagram 4D) describes the need to have a systematic approach to developing competency of all site personnel, including supervisors.

The Communication Process (Diagram 4D) should ensure that the supervisors are aware of any issues or changes that may affect the risk.

These two Management elements should ensure that, on the day, there are competent, knowledgeable supervisors for the tasks.

This element of the model, Supervision, suggests that leadership on the day must also be adequate to control the risks. The supervisory role is the most visible indicator of corporate and site commitment to safety and health risk management. If the visible image is production first, for example, the effectiveness of the entire risk management system can be greatly reduced. Clear front-line leadership based on the Safe Production goal and site policy is the aim.

4.5.9 Personnel Performance

The Management System Process titled Competency Process (Diagram 4D) describes the need to have a systematic approach to selection and competency development for all site personnel.

The Communication Process (Diagram 4D) should ensure that all relevant personnel are aware of any issues or changes that may affect the risk.

These two Management elements should ensure that, on the day, there are competent, knowledgeable personnel for the tasks.

This element of the model, Personnel Performance, suggests that execution of tasks on the day is also dependent on factors other than knowledge and skill.

The first stage in ensuring effective Personnel Performance involves adequate Task Assignment. In theory, the individual must be made aware of the task to be performed and the expected outcomes. This may include the method, equipment, timing and other resources.

Task Assignment should also include communication between the supervisor and the personnel identifying hazards that are unusual or might be otherwise unexpected by the individual.

Very often Task Assignment is informal with little or no input from supervisors concerning the issues mentioned above. Human error may be initiated at this point in the task in several ways:

- The person may inadvertently err due to inattentiveness or distraction where better Task Assignment would have warned the person of the hazards, increasing attentiveness
- The person may select an action that is incorrect for the situation because he/she is not aware of the requirements or the changes
- The person may not recognise that a rule is particularly important for the task or that a generally accepted site violation of a rule is not appropriate for this task

There are several areas that affect the quality of **Task Execution**, related to Personnel Performance, once the Task Assignment is completed:

- Individual competency
- Fitness for work
- Attitudes and Culture
- Motivation

Individual Competency refers to the knowledge and skills of the individual worker in relation to the requirements of the task. Successful Task Execution requires competency relevant to the task at hand. Human error may be initiated due to lack of competency in several ways.

The Competency Process (Diagram 4D) and Supervision (Diagram 4E) should ensure that the person is appropriately competent for the task at hand.

Fitness for Work refers to the state of the individual in relation to the requirements of the task. It includes anatomical, physiological, biomechanical and psychological fitness.

The employee selection aspect of the Competency Process (Diagram 4D) addresses the process of selecting persons suitable for employment at the site. Day-to-day Fitness for Work refers to issues after the person is employed.

Following are some of the factors that affect Fitness for Work:

- Aging
- Health Problems
- Past Injuries
- Alcohol and Drugs
- Mental Stress
- Work hours/shift work effects

Any of the above can potentially change the risk in a task.

Simply defined, **attitude** is a relatively enduring organisation of beliefs, feelings and behavioural tendencies towards socially significant objects, groups, events or symbols. Colloquially, health and safety attitude may be thought of as the individual innate, slowly developed beliefs about the importance, relevance and consequences of following the sites rules, standards and expectations.

Culture is a set of attitudes. In other words, the attitudes of a group of people combined and, more or less, averaged to identify the group norm. Again colloquially, it is "the way we do things around here" to address safety and health risks. There can be organisational and work group cultural issues.

Even an ideal textbook risk management system is unlikely to succeed if the attitudes and culture areas are not supportive. For example, if existing work practices conflict with new risk assessment based SOPs, a negative culture may lead to high resistance to change. Even in engineering and management there may be cultural resistance to documenting and following the expected Management System Applications (Diagram 4A).

Some aspects of this model should support, even help develop, a positive culture. These include the systematic approach to management and, specifically, the requirement for <u>participation</u> in risk assessments and the development of standards documentation. The many feedback loops in the various processes should also increase personnel <u>input and ownership</u> in the mine or site.

Measuring the workplace health and safety culture can be done by survey or interview techniques that ask a cross-section of personnel to give honest opinions about various safety and health issues. Issues that can be queried include perceptions of management commitment, adherence to safety rules, availability of safety related equipment, effectiveness of initiatives to improve safety and the impact of communication initiatives.

Negative safety cultures that try to put in place a new Risk Management System may need to utilise overt approaches such as the following.

- Involvement of as many personnel as possible in development phases of the new system

- Involvement of labour representation in regular decisions
- Direct communication of progress and issues to all personnel
- Use of a no blame approach to incidents, accidents and near miss events (unless negligence is absolutely clear) to both management and employees

More guidance on matching the risk management system to the culture is provided in Chapter 3 of this document, The Risk Management Journey.

Motivation is a term generally used to describe the psychological reasons why people behave or act as they do. For example, a person is motivated to do something or not to do something. Sometimes we ask about a person's motivation after they have acted in an unexpected way.

Like attitude, motivation is not always relevant to unwanted behaviours. Tripping on a step or miss-operating a control will not occur due to motivation.

Motivation and attitude are major research topics. The minerals industry is only beginning to incorporate some of this information into day-to-day operations. For the purpose of this guideline it is important to recognise that an organisation with an integrated Risk Management approach such as the one described in this Section will have a resilient culture where individual motivation will be positive.

As covered in Chapter 3 of this document, The Risk Management Journey, James Reason (1997) suggests that a resilient culture, with its resultant positive motivators, is informed, reporting, just, flexible, learning and also wary.

- An *informed culture*: one which those who manage and operate the system have current knowledge about the human, technical, organisational and environmental factors that determine safety of the system as a whole.
- A *reporting culture*: a culture in which people are willing to report errors and near misses.
- A *just culture*: a culture of "no blame" where an atmosphere of trust is present and people are encouraged or even rewarded for providing essential safety-related information – but where there is also a clear line between acceptable and unacceptable behaviour.
- A *flexible culture* which can take different forms but is characterised as shifting from the conventional hierarchical mode to a flatter professional structure.
- A *learning culture*: the willingness and the competence to draw the right conclusions from its safety information system, and the will to implement major reforms when the need is indicated.
- A *wary culture*: where everyone is always alert to expect the unexpected and there is a desire to continuously improve as demonstrated by activities such as benchmarking.

The above points describe an image of the “way of life” culture required for a successful integrated risk management system.

4.6 Key points from this Chapter

This section offered an image of a future fully integrated risk management approach to minerals site operations. This image is consistent with the Resilient rung of the Hudson and MIRM ladders discussed in Chapter 3.

The Minerals Industry–Integrated Risk Management (MI-IRM) model suggests that there are five major areas where risk management, sometimes transparently, is included in both design and execution of site activities and processes. The five major areas are:

- Corporate and Site Direction (Chapter 4.1)
- Site Risk Assessment Approach (Chapter 4.2)
- Management System Applications (Chapter 4.3)
- Hazard Specific Barriers (Chapter 4.4)
- Day to Day Management Processes (Chapter 4.5)

The MI-IRM model is intended to supply an image of the future that may assist in defining long-term goals and objectives. The reader can use this model to ascertain the gap between current status and this future ideal either through using the information in Chapter 4 or a more basic audit approach included in the appendices.

The MI-IRM model completes this guideline offering a full site model to enhance previous information on the general risk management process and the step by step guidance on undertaking the journey to resilient, integrated risk management.

Chapter 5 References

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Chapter 6 Appendices

6.1 Definitions of terms and acronyms

AS – Australian Standard

Acceptable risk - The residual risk remaining after controls have been applied to associated hazards that have been identified, quantified to the maximum extent practicable, analysed, communicated to the proper level of management and accepted after proper evaluation (Stephenson, 1991)

ALARP – As low as reasonably practical

Assumed risk - A specific, analysed residual risk accepted at an appropriate level of management. Ideally, the risk has had analysis of alternatives for increasing control and evaluation of significance of consequences (Stephenson, 1991)

BTA – Bow Tie Analysis

Barrier - Anything used to control, prevent, or impede energy flows. Types of barriers include physical, equipment design, warning devices, procedures and work processes, knowledge and skills, and supervision. Barriers may be control or safety barriers or act as both. (Stephenson, 1991)

Consequence - The outcome of an event expressed qualitatively or quantitatively, being a loss, injury, disadvantage or gain. There may be a range of possible outcomes associated with an event.

Cost - Of activities, both direct and indirect, involving any negative impact, including money, time, labour, disruption, goodwill, political and intangible losses.

Criticality - The categorisation of a hardware item by the worst case potential direct effect of failure of that item. In assigning hardware criticality, the availability of redundancy modes of operation is considered. Assignment of functional criticality, however, assumes the loss of all redundant hardware elements. (Stephenson, 1991)

DII – The NSW Department of Industry and Investment

EBA – Energy Barrier Analysis

ERP – Emergency Response Plan

Event - An incident or situation, which occurs in a particular place during a particular interval of time.

Event Tree Analysis (ETA) - A technique which describes the possible range and sequence of the outcomes which may arise from an initiating event.

FMEA – Failure Modes and Effects Analysis

FMECA – Failure Modes, Effects and Criticality Analysis

FTA – Fault Tree Analysis

Failure Modes and Effects Analysis (FMEA) - A procedure by which potential failure modes in a technical system are analysed. An FMEA can be extended to perform what is called failure modes, effects and criticality analysis (FMECA). In a FMECA, each failure mode identified is ranked according to the combined influence of its likelihood of occurrence and the severity of its consequences

Fault Tree Analysis (FTA) - A systems engineering method for representing the logical combinations of various system states and possible causes which can contribute to a specified event (called the top event).

Formal safety assessment (FSA) - A formal investigation of the nature, likelihood and impact of (FSA) potential major accident events and the means to prevent or minimise their occurrence or consequences to as low as reasonably practicable. Within the context of the safety case the term "formal safety assessment" may also refer to the reporting of facility-specific studies conducted by the operator that provide reasoned arguments and judgements about the findings of the formal investigation. (Australian Dept. of Industry, Science and Resources, 2004)

Frequency - A measure of the rate of occurrence of an event expressed as the number of occurrences of an event in a given time. See also Likelihood and Probability.

HAZAN – Hazard Analysis Study

HAZOP – Hazard and Operability Study

Hazard and Operability Study (HAZOP) - A structured brainstorming approach to identifying both hazards and operability problems. The study, carried out by a multidisciplinary team, is applicable to any situation which can broadly be described as a process. The objective is to complete a comprehensive and systematic study of a facility, section by section, evaluating the significance and consequence of deviations from the design intent. It is a brainstorming process, using guidewords, and based, usually, on flow, process and instrumentation diagrams

Hazard - A source of potential harm (

H&S Planning Programs – Health and Safety Planning Programs

JHA – Job Hazard Analysis (Another name for Job Safety Analysis)

JSA – Job Safety Analysis. A JSA is a task oriented risk assessment which can be applied by a work team prior to undertaking a potentially hazardous activity. Generally the technique is applied on site for routine activities as a precursor to a safe working procedure. It uses job observation and experience as the basis for identifying hazards and controls to be used.

LTIFR – Lost Time Injury Frequency Rate

Likelihood - Used as a qualitative description of probability or frequency.

Loss - Any negative consequence, financial or otherwise.

MCA – Minerals Council of Australia

MDG – NSW DII Mine Design Guideline

MI-IRM Chart – Minerals Industry – Integrated Risk Management chart

MIRM ladder – Minerals Industry Risk Management ladder or maturity chart.

MIRMgate – Minerals Industry Risk Management gateway database system available at www.mirmgate.com

MISHC – Minerals Industry Safety and Health Centre at the University of Queensland.

MSDS – Material Safety Data Sheet

Monitor - To check, supervise, observe critically, or record the progress of an activity, action or system on a regular basis in order to identify change.

NMISHRAG – National Minerals Industry Safety and Health Risk Assessment Guideline available at www.mishc.uq.edu.au

NASA – National Aeronautics and Space Administration

NSW – New South Wales

OHS – Occupational Health and Safety

OHSM – Occupational Health and Safety Management

OHSR – Occupational Health and Safety Regulation 2001

OHSWR – Occupational Health, Safety and Welfare Regulations (S.A.)

Organisation - A company, firm, enterprise or association, or other legal entity or part thereof, whether incorporated or not, public or private, that has its own function(s) and administration.

PHA – Preliminary Hazard Analysis

Probability - The likelihood of a specific event or, outcome measured by the ratio of specific events or outcomes to the number of possible events or outcomes. Probability can be expressed as a number between 0 and 1, with 0 indicating an impossible event or outcome and 1 indicating an event or outcome that is certain.

QRA – Quantitative Risk Assessment

RCM – Reliability Centred Maintenance

Residual risk - The remaining level of risk after risk treatment measures have been taken.

Risk - The effect of uncertainty on objectives. It is measured in terms of consequences and likelihood. (AS/NZS ISO 31000:2009)

Risk acceptance - An informed decision to accept the consequences and the likelihood of a particular risk.

Risk analysis - A systematic process to comprehend the nature of risk and to determine the level of risk. (AS/NZS ISO 31000:2009)

Risk assessment - The overall process of risk identification, risk analysis and risk evaluation. (AS/NZS ISO 31000:2009)

Risk avoidance - An informed decision not to become involved in a risk situation.

Risk-benefit analysis - Evaluation of risks and benefits of some activity or agent usually based on economic consideration.

Risk evaluation - Process of comparing the results of risk analysis with risk criteria to determine whether the risk and/or its magnitude is acceptable or tolerable (AS/NZS ISO 31000:2009)

Risk identification - The process of finding, recognizing and describing risks . (AS/NZS ISO 31000:2009)

Risk management - The coordinated activities to direct and control an organization with regard to risk. (AS/NZS ISO 31000:2009)

Risk management framework - The set of components that provide the foundations and organizational arrangements for designing, implementing, monitoring, reviewing and continually improving risk management throughout the organization (AS/NZS ISO 31000:2009)

Risk reduction - A selective application of appropriate techniques and management principles to reduce either likelihood of an occurrence or its consequences, or both.

Risk treatment - Selection and implementation of appropriate options for dealing with risk.

SOP – Standard or Safe Operating Procedure

SSDC – System Safety Development Centre

SWP – Standard Work Practices

TARPS – Triggered Action Response Points

WRAC – Workplace Risk Assessment and Control

6.2 Self assessment tools for the MIRM Ladder

Use the chart to identify the sites status

	Vulnerable	Reactive	Compliance Driven	Proactive	Resilient
Informal Risk Assessment	No informal risk assessment is done. People start the job without thinking about hazards and risks.	A site method for informal risk assessment has been introduced but there is very little application by the workforce before starting a job.	The sites informal risk assessment method is followed by many due to the compliance focus though most do not recognise the value.	The sites informal method is followed by most and seen, by many, to be a valuable step in doing each job	Virtually everyone on the site, at all levels, applies the site method for informal risk assessment in any task where unacceptable risks may exist and it is done almost automatically.
Formal Risk Assessment	No formal risk assessment is done. Most, if not all, site activities, methods and plans, are not documented and none have been systematically reviewed to consider hazards, risks and controls.	A site method for risk assessment has been introduced and is being applied sometimes after an accident or when suggested by a regulator or company manager. There is no systematic use of risk assessment.	The site's formal risk assessment methods are documented as a site procedure and followed by many due to the compliance focus though most do not recognise the value. Risk assessment is done often.	The sites formal risk assessment procedure is followed by most and seen, by line management, to be a valuable part of doing their job. Line managers are targeting the assessments on key issues.	Risk Assessment is no longer a procedure but rather transparently integrated in procedures for key site systems such as purchasing, design, planning, maintenance, etc. It is part of the way decisions key are made.

	Vulnerable	Reactive	Compliance Driven	Proactive	Resilient
Incident and Accident Investigation	Investigation of accidents (events where someone is hurt) occurs when required by insurance and/or government requirements. Investigation is very superficial.	Investigation of accidents occurs when there is an injury or loss as required by the site or company. Investigation is still superficial, focussing on what people did wrong at the time of the event rather than management systems problems.	Investigations are done on accidents and incidents (no losses but significant potential for losses). The investigation process gathers information on causes other than behaviour such as upstream decisions about work methods, training , equipment status or the work environment	All incidents are effectively investigated with a level of investigation that is selected based on the potential rather than actual outcome. The investigation process is systematic in considering human errors and management systems issues. Action plans are developed and actions followed up.	All incidents are very effectively investigated with a level of investigation that is selected based on the potential rather than actual outcome. The investigation process is open with all levels involved and the learning's are openly shared across the site.
Incident and Accident Analysis	No analysis of investigation information is done.	Limited analysis is done on accident information, possibly as a one-off due to a perceived need to address a problem such as back injuries.	Some analysis is done of incidents and accidents to regularly identify priority issues	Targeted ongoing incident analysis is done based on the input of line managers	Continual analysis of accidents and incidents is done to provide an open and accessible insight into events, their causes and required changes.

	Vulnerable	Reactive	Compliance Driven	Proactive	Resilient
Monitoring of Behaviour	No monitoring of behaviour is done.	Programmes to monitor behaviour have been introduced but are ineffective since they are not supported and followed.	Programmes to monitor behaviour are done with some success but there is limited targeting of monitoring on key behaviour issues	Well defined, priority behaviours are monitored systematically with effective feedback provided to a receptive workforce.	All behaviours are monitored by all in a work situation where the safe way is the way we do business. Peers, supervisors and others monitor a workforce keen to do it right.
Auditing of Expectations	No auditing to expectations is done.	Ad hoc audits are done to expectations though the expectations are not ideal for the purpose. Auditing is reactive to drivers such as accidents or external stakeholders.	Audits to OH&S standards are done by the site and/or by external personnel. The audit focuses on the OH&S standards rather than targeting priority risk issues.	Well defined, priority auditing is done on a regular basis. Priority issues have been established with the input of line management.	The key management systems, with integrated risk assessment, are effectively audited on a regular basis because all recognise their importance to the safe production of the site.
Culture	No care - apathy, resistance, negligence, dishonesty, hiding of incidents	Blame - acceptance off need to "care" but focus is on discipline and "blame the bloke"	Compliance - acceptance of need to comply but lack of real ownership	Ownership - safety is owned by line managers rather than the safety department. Others see the value.	Way of life - safety is the way we do things. Everyone thinks before they act and proudly does the work to expectations.

Remember – the systems cannot effectively progress beyond the status of the culture

6.3 MI-IRM Model Audit Information

The following information is intended to give basic audit guidance for auditable boxes in the MIRM tree.

Tree item	Basic Audit Criteria
Corporate and Site Direction	The auditor should look for corporate and site level direction and context setting information in the following areas.
Corporate Policy, Criteria, Resources and Communication	The auditor must try to identify the degree to which the company and site are overtly committed to effective risk management. Very often interviews with corporate or site management to identify company and site goals related to risk management are relevant. The site should also have a Business Plan that should indicate commitment through relevant goal statements, strategies, objectives, targets and resource commitments.
Site Policy & Implementation	The auditor should look for clear direction on risk management activities, usually expressed in the form of OH&S and / or Risk Management Policy. The Policy should include or be supported by criteria for application, criteria for risk management (including acceptability of risk) and mechanisms to communicate the Policy and criteria to the relevant personnel.
Budgetary Planning Process	The auditor should look for demonstrated consideration of site risk management in budget planning through inclusion of budgeting for improved controls and systems identified in the process.
Goals for the Risk Management System	The auditor should look for goal statements in corporate, site and possibly department management plans that effectively indicate the direction for the relevant risk management approach. These goals should be incorporated into business plans and the plan should include information derived with the intent of meeting the goals.
Risk Register and Hazard Information	The auditor should look for information that demonstrates that the site has identified and examined the site hazards and risks, such as a site risk register. The information should also demonstrate that the site has invested appropriate resources in looking for hazards, gathering information to deduce the hazard magnitudes, as well as acquiring and communicating relevant information about the hazards and priority site risks.
Risk Management Performance Measurement	The auditor should look for a documented set of performance measures with targets, as well as a clear and effective method of gathering, analysing and reporting performance information.
Review Programme - Incident/ Accident Investigation	The Auditor should look for a documented Incident / Accident Investigation Process that includes defined levels of investigation, specific to an actual or potential outcome. The process should include derivation of actions to improve after the event, as well as feedback to the workforce and follow up review to ensure actions are implemented
Review Programme - Auditing	The auditor should look for a documented auditing process that includes the areas to be audited, the schedule, the resources and the action planning / feedback approach to be followed with each audit.

Tree item	Basic Audit Criteria
Site Risk Assessment Approach	The auditor should look for a set of standards at the site which outline the processes to be followed to identify hazards, analyse risk and deduce controls for new designs, acquisitions, maintenance and other site requirements. They should include one or more risk assessment techniques, a method of pro-actively considering human factors issues and a method to consider risks when drafting or reviewing work procedures.
Risk Acceptability Criteria	The auditor should look for a corporate or site method for assessing risk either by quantitative or semi-quantitative means. This method should include a defined acceptability level where corporate or site Policy indicates that no further action is required to reduce the risk. Guidance for determining the acceptability of risk when that outcome is required should also be demonstrated.
Life Cycle Requirements	The auditor should look for company or site guidance that indicates commitment to assessing and controlling risk early in the life cycle. Commitments and guidance for risk assessment in project management, or design / acquisition and construction phases indicates that approach.
Human Factors Review	The auditor should look for a corporate or site standard which appropriately addresses a method for considering human factors in the management system. At this point, the auditor is not looking for supervisor training or site discipline approaches but rather a method of deducing possible human errors in the design of the workplace.
Informal Risk Assessment	The auditor should look for a corporate or site standard for Hazard Identification. This “standard” should include the mental model as well as the systematic applications to ensure persons are competent, encouraged to apply the model and reported hazards are addressed in a timely and open manner.
Job Safety Analysis	The auditor should look for a documented procedure for Job Safety Analysis. This may be part of a procedure for deriving and documenting Standard Operating Procedure (see Element MD8). The JSA Procedure should give clear guidance on the method of doing a JSA, including any forms.
Formal Risk Assessment	The auditor should look for corporate or site standards for risk assessment methods. These standards should include the detail of setting up (scoping) the resource requirements, operating the process and dealing with the outcomes. Depending on the nature and operating status of the site, the risk assessment tools should suit the specific needs. Sites with complex hardware such as minerals processing plants should minimally have HAZOP, while more labour intensive operations such as underground mines should minimally have a Hazard Analysis method. It is desirable that the site risk assessment techniques should be outlined in a standard document in the site Risk Management document.

Tree item	Basic Audit Criteria
Management Systems Applications	The auditor should look for a documented set of engineering and management processes that define, at least, the following major sub-elements below. These procedures may not be a part of the Risk Management Manual since they cover more than the management of risk. However, there should be information in the Risk Management Manual that identifies the requirements in these processes and cross–references to the main document.
Communication Process	The auditor should look for a documented outline of the site communication process that addresses the site-specific risk management needs. This might include identification of various written and non-written methods to inform the various parts of the workforce about new or changing risks, as well as mechanisms to retrieve workplace input on hazards.
Design, Modification and Acquisition Process	The auditor should look for a documented set of procedures dealing with the methods of designing / planning, modifying or purchasing for the site requirements. As previously mentioned, these procedures may not be located in the Risk Management Manual but rather in Engineering / Acquisition Procedures for the site. The procedures should include risk assessment where significant risks may be present. The auditor should look for a mine or site planning procedure that defines the method by which new plans or changes to plans are derived. Inherent in the procedure the auditor should find criteria for assessing risk based on potential hazards. The procedure should suggest one or more tools for assessing risk, as well as resource / expertise requirements and direction on application of results from the risk assessment. The auditor should look for plant design and modification procedures that define the method by which new designs or changes to plant are derived. Inherent in the procedure the auditor should find criteria for assessing risk based on potential hazards. The procedure should suggest one or more tools for assessing risk, as well as resource / expertise requirements and direction on use of results from the risk assessment. The auditor should look for an acquisition or purchasing procedure that defines the method by which purchasing of plant, equipment and materials is done. Inherent in the procedure the auditor should find criteria for assessing risk based on potential hazards. The procedure should suggest one or more tools for assessing risk, as well as resource/expertise requirements and direction on use of results from the risk assessment.
Materials (Design & Modification)	The auditor may have already identified and reviewed the Acquisition or Purchasing Procedure as part of ME6. In addition, material safety and health criteria, especially the use of MSDS information should be included.
Maintenance Process	The auditor should look for a documented maintenance planning process that includes provision for considering risks to personnel, assets and production. As previously mentioned, the procedure may not be in the Risk Management Manual.
Inspection & Monitoring Process	An auditor should look for defined Inspection and Monitoring Procedures, focussing on site risks. Inspection procedures that target critical plant or equipment should exist. Monitoring of behaviour may

Tree item	Basic Audit Criteria
	be targeted through selection of major suspected sources of human error. Monitoring of hazards should be especially targeted on major hazards where status monitoring is the key to management.
Documentation Process	The auditor should look for a site method for identifying, developing, integrating and reviewing work method standards Ideally, this process would be documented in a site documentation development "standard". In addition, the site documentation process should include documentation of engineering and management tasks that involve decisions where significant risks can be inadvertently assumed. These documents should include requirements for pro-active analysis to consider risks.
Competency Process	The auditor should look for demonstrated application of a systematic selection process that considers the points made above. The auditor should look for a documented competency approach that clearly identifies competency requirements for the site and the process by which this is managed. Documented competency information may reside inside the site Training Activity. Auditors should look for the training materials and record system. The goal would be information covering all significant tasks and all employees.
Emergency Response Process	The auditor should identify and examine the Emergency Response Plan. The process by which the ERP was developed should also be reviewed. Ideally, there should be a traceable process that allows the auditor to understand the potential events and therefore the basis for the ERP. The ERP should give clear, effective direction to those persons which can be affected by the event and those who must take action should the event occur. ERP content should be included in induction and other training. It should also be available for referral where required.
Change Management Process	The auditor should identify and examine the procedures adopted when change is being considered or implemented. The procedure should clearly identify when it can be by-passed. It should detail who is authorised to sign-off on the risk management steps that must be included before modification sign-off will be granted
Contractor Management Process	The Auditor should identify the contract requirements for the supplier / service provider to carry out risk assessment and implement the necessary defensive barriers against unwanted outcomes. Critical check points for the principal should also be evident and they should address all critical outcomes.

Tree item	Basic Audit Criteria
Hazard Specific Barriers	Auditors should look for a systematic approach to identifying site and process hazards followed by a logical framework for defining effective barriers. The auditor should look for corporate and site recognition that there must be a systematic approach to deducing required Barriers and ensuring that Controls are in place to optimise the Work Process. Broad Brush Risk Assessments or other site risk assessment techniques are often used to deduce the major hazards that must have defined Barriers. Other review methods such as Operational Risk Assessments and Job Safety Analysis can be used to examine the site risks in more detail. The auditor should be wary of approaches to Barrier definition that depend too much on procedures or practices, as well as over dependency on 1st and Emergency Response. Also, some hazards may not be adequately understood by the site, leading to incorrect and potentially dangerous assumptions.
Prevention Barriers	Auditors should look for optimal Prevention Barriers for the unacceptable risks at the site. Examination of Prevention Barriers for the highest site risks should be the priority for the auditor, followed by identification of the site approach to deducing hazards and Prevention barriers.
Monitoring Barriers	Auditors should look for optimal Monitoring Barriers for the unacceptable risks at the site. Examination of Monitoring Barriers for the highest site risks should be the priority for the auditor, followed by identification of the site approach to deducing hazards and Monitoring barriers. Auditors should carefully identify the degree to which monitoring is executed to the required standard. For example, gas monitors may be in place but data may not be gathered and trended to use the system effectively.
1st Response Barriers	Auditors should look for optimal 1st Response Barriers that give early indication that an unwanted event MAY be underway (ex. TARPs, temperature sensor triggers, earth leakage, etc.) for the unacceptable risks at the site. Examination of 1st Response Barriers for the highest site risks should be the priority for the auditor, followed by identification of the site approach to deducing hazards and 1st Response barriers. Auditors should carefully identify the degree to which 1st Response Barriers are in place as per the required standard. For example, gas monitoring alarms may be in place but turned off.
Amelioration Barriers	Auditors should look for optimal Amelioration Barriers for the unacceptable risks at the site. Examination of Amelioration Barriers for the highest site risks should be the priority for the auditor, followed by identification of the site approach to deducing hazards and Amelioration barriers. Auditors should carefully identify the degree to which site personnel are aware of the Emergency Response Plan and trained in relevant aspects of the plan.

Tree item	Basic Audit Criteria
Day to Day Management Processes	Auditors should look for activities in the following specific areas of the management process that, at the time of the work, ensure that competent people have appropriate methods and fit-for purpose equipment in an environment controlled physically and through effective supervision.
Hazard Status	The auditor should look for practical demonstration that the individual is aware and competent related to all expected hazards in his/her tasks. There should also be demonstration that a systematic method of informally looking for and acting on hazards is applied in the individual's approach to work.
Equipment Operability	The auditor should look for practical demonstration that the correct plant and equipment is used for the task. Issues such as use of incorrect plant or equipment due to lack of availability should be explored to understand the cause from a management systems standpoint.
Materials Quality	The auditor should look for practical demonstration that the correct materials are used for the task. Storage, transportation, containers, access for loading / unloading, application and clean up are some example areas to be observed. Special attention should be paid to chemicals on the site with significant hazards as indicated by MSDS information.
Maintenance Status	The auditor should look for practical demonstration that the correct maintenance is being done, as per the site Maintenance Plan. Maintenance records as well as the execution of maintenance tasks should be observed versus the "standard".
Inspection / Monitoring	The auditor should look for practical demonstration that engineers, managers and supervisors informally observe the work processes of the site. In addition, the auditor should look for situations where adherence issues exist and comment is made to rectify the situation by site personnel.
Work Procedures	The auditor should look for practical demonstration that the correct procedures or guidelines are used for the task. Mechanisms to review and adjust the procedure if conditions indicate that it cannot be followed.
Environment Operability	The auditor should look for practical demonstration that the correct work environment exists for the task, including air quality, traffic control, lighting, accessibility, etc. Issues such as failure to address a required change in work environment requirements should be explored to understand the cause from a management systems standpoint.

Tree item	Basic Audit Criteria
Personnel Performance	The auditor should look for practical demonstration of the issues identified in the following elements. NOTE: For the purposes of his basic audit tool, all Personnel Performance issues from the MI-IRM model have been listed together
Supervision	The auditor should look for practical demonstration that supervisors are competent and knowledgeable in the work they control. In addition, the auditor should try to observe supervisor behaviour that indicates commitment to safety and health risk management, as per the company or site policy.
Fitness for Work	The auditor should look for practical demonstration that the establishment of Fitness for Work is part of the site management system. Demonstrated methods to address issues suggested by the 6 listed examples would be desirable.
Competency	The auditor should look for practical demonstration of competency for the task. This can be done by observing personnel in a task to see if they perform adequately, as well as asking about the basis of their competency.
Culture	Auditors will get a feel for the safety and health culture of a mine or site as they observe some of the Work Process areas described previously. Auditors can also take a basic survey of culture by asking a cross section of personnel to provide their honest (confidential) perceptions of issues like those listed above.
Motivation	Individual motivation is not usually an area for system auditing. The auditor should use the overall results of the audit to conclude whether the antecedents and consequences are generally appropriate for the site.
Task Assignment	The auditor should look for practical demonstration of effective Task Assignment. This can be done by observing pre-task supervisor discussions or by asking personnel if they received clear direction for the task at hand.
Task Preparation	The auditor should look for practical demonstration of effective Task Preparation. This can be done by observing pre-task supervisor discussions and actions or by asking personnel if there had been adequate preparation prior to receiving their assigned tasks.
Task Quality Assurance	The auditor should look for practical demonstration of effective Task Quality Assurance by Supervisors. This can be done by observing post-task supervisor/personnel discussions and actions or by asking personnel if there had been either reinforcement or corrective feedback following completion of their assigned tasks.

6.4 Contents of the National Minerals Industry Risk Assessment Guideline

National Minerals Industry
Safety and Health Risk Assessment Guideline (NMISHRAG)
Version 4 - Jan 2005

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JSA or Job Safety Analysis
CHAIR Construction Hazard Assessment and Implication Review
Energy Barrier Analysis (also called Energy Trace Barrier Analysis)
Consequence Analysis (also called Cause-Consequence Analysis)
Human Error Analysis

Appendix H. Fatigue Risk Assessment Process

6.5 Assessing the quality of a risk assessment scope (design document)

Scope - A good Scope should include the following:

- An objective based on the expected deliverable
- A description of the system to be reviewed and clear identification of the boundaries
- An inventory of the potential hazards
- A statement of external threats
- A listing of assumptions
- Identification of consequences of interest
- The risk assessment method – the means of identifying the unwanted events
- The risk analysis method – the means of calculating and examining the level of risk
- The facilitator for the risk assessment
- The scribe for the risk assessment
- The risk assessment team or work group (identifying reasons for inclusion)
- The time required (and venue)
- The means of providing risk assessment results and the desired deliverable

Consultant Proposal Checklist - A good Consultant Proposal should include the following:

- Background information on the issue and the need for risk assessment
- An objective based on the expected deliverable
- An overview of the system to be reviewed
- An inventory or overview of the potential hazards
- The risk assessment method – the means of identifying the unwanted events
- The reason for selection of the risk assessment method
- The risk analysis method – the means of calculating and examining the level of risk
- The reason for the selection of thee risk analysis method
- The qualification of the consultancy to carry out the works scoped
- The facilitator for the risk assessment with detail of qualification for the assessment
- The suggested risk assessment team membership
- The time required for preparation, the exercise and the write up
- The suggested location / venue for the exercise
- The means of providing the risk assessment results
- Costs and dates for the project

6.6 Guidelines for assessing the quality of a risk assessment report

Report Format Checklist

A good Report should include the following:

- Executive Summary
- Introduction
- Context strategic, corporate and risk management
- Issues / reasons for review
- Objective
- Method (and reason for choice of method)
- Team (names, positions and related experience)
- Hazard inventory table
- External threats
- Core assumptions
- System description, boundaries and documentation
- Risk identification technique and reason for choice
- Risk analysis method and reason for choice
- Results (tables, charts, etc.)
- Priority risks by magnitude of risk and consequence
- Priority existing controls and performance indicators
- Priority new controls and performance indicators
- Recommended Action (the Action Plan information)

6.7 Risk Assessment Report Review Checklist[1]

A review of a risk assessment should consider the following issues

- Is the reason for the review defined?
- Are the objectives of the review stated?
- Is there a description of the system being assessed?
- Are the boundaries clearly and unambiguously defined?
- Is the documentation provided sufficient to understand the scope and function of the system?
- Is there a summary of the strategic, corporate and risk management context?
- Are the participants identified together with their organisational roles and experience related to the matter under consideration?
- Is the range of experience/expertise of the team appropriate?
- Is the facilitator identified together with related experience?
- Is the facilitator appropriate?
- Is the method of identifying the risks clearly identified?
- Is the reason for the choice of methodology explained?
- Is the method of assessing likelihood and consequence of the risks identified?
- Is the reason for the choice of methodology explained?
- Is there a hazard inventory table?
- Is there a listing of external threats?
- Are all the core assumptions identified?
- How was the acceptability of the risks determined?
- Is the determination of the acceptability of the risks justifiable?
- Are all the risks prioritised by risk magnitude and consequence magnitude?
- Was the hazard identification process comprehensive and systematic?
- Has the approach to each part of the study been consistent?
- Have all the existing controls and performance indicators been identified and their function determined accurately?
- Have all potential new controls been identified, adequately assessed and assigned performance indicators if adopted?
- Is there a recommended action list giving actions, responsibilities and timelines for completion?
- Is there a review process to ensure the assessment is consistent with others completed at the same facility/business?

[1] Adapted from MDG1014

Feedback Form

Your comment on this Guideline for Minerals Industry Safety and Health Risk Management will be very helpful in reviewing and improving the document.

Please copy and complete the Feedback Form and return it to:

Senior Inspector – Mechanical Engineering
Mine Safety Operations
Industry and Investment NSW
PO Box 344
Hunter Region Mail Centre NSW 2310
Australia
Ph: 4931 6666
Fax: 4931 6790

How did you use, or intend to use, this Guideline?

What do you find most useful about the Guideline?

What do you find least useful?

Do you have any suggested changes to the Guideline?

Thank you for completing and returning this Feedback Form