TO BE UPDATED TO REFLECT LATEST LEGISLATIVE CHANGES

GOOD PRACTICE GUIDELINES

# Health and Safety at Opencast Mines, Alluvial Mines and Quarries

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New Zealand Government

WORKSAFE NEW ZEALAND | MAHI HAUMARU AOTEAROA

**These good practice guidelines give practical advice on health and safety controls measures at opencast mines, alluvial mines and quarries.**


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# HEALTH AND SAFETY AT OPENCAST MINES, ALLUVIAL MINES AND QUARRIES KEY POINTS:

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**Have a well-planned, designed and maintained work site, with a suitable hazard management system**

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**All workers must be trained and competent for the work they do, including the required certification**

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**Notify the site location and nature as well as the manager's details to WorkSafe**

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**Use in guard nip guarding for conveyors, as well as idler nip guards**

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**Where end tipping, ensure there is a safe tipping procedure and the tip has been designed with a Factor of Safety of at least 1.2**

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**Provide separate roads for light and heavy vehicles, where practicable. Otherwise, ensure they are segregated**

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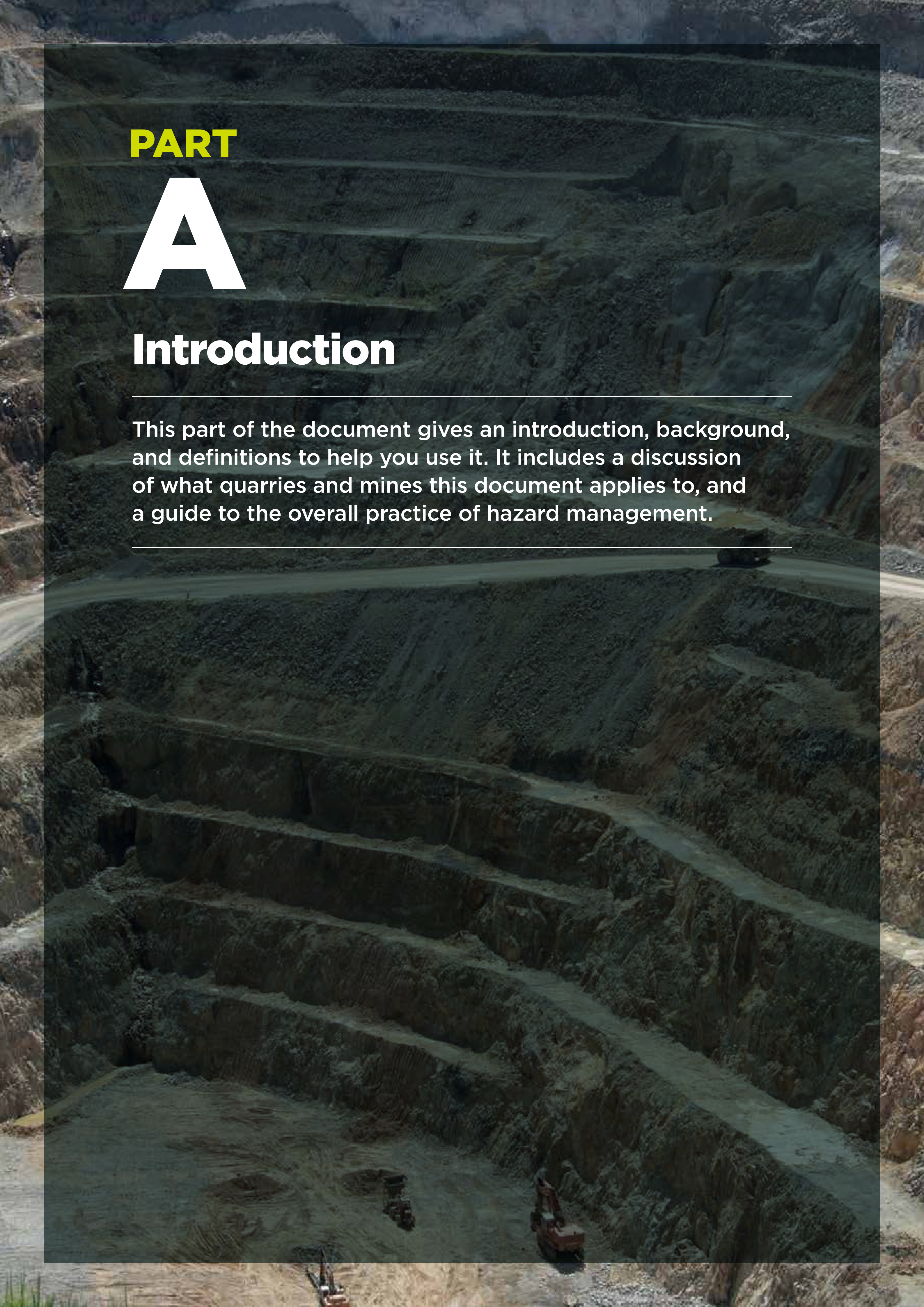
# PART A

# Introduction

This part of the document gives an introduction, background, and definitions to help you use it. It includes a discussion of what quarries and mines this document applies to, and a guide to the overall practice of hazard management.



PART A

# 01/

# INTRODUCTION

## IN THIS SECTION:


1.1 How to use this guidance

1.2 Background

1.3 Purpose

1.4 Scope and application

1.5 Interpretation

1.6 Safety-critical roles

**This guideline is about helping you implement hazard controls for risks commonly associated with opencast mines, alluvial mines and quarry operations.**

## 1.1 HOW TO USE THIS GUIDANCE

This document has four parts:

### PART A: INTRODUCTION

This part gives an introduction, background, and definitions to help you use this document. Part A includes a discussion of what quarries and mines this document applies to, and guidance on the overall practice of hazard management.

### PART B: PLANNING AND DESIGN

This part provides guidance on planning safety into mine and quarry operations. It describes in detail how to plan excavations, tips, ponds, dams, roads, and vehicle operating areas.

### PART C: OPERATIONAL SAFETY FOR MINING AND QUARRYING

This part sets out site safety practices for working with explosives, managing ground instability, tipping and dumping material, storing water and tailings, and managing traffic.

### PART D: EMERGENCY MANAGEMENT AND OPERATIONAL SAFETY FOR EQUIPMENT AND PEOPLE

This part provides guidance on managing machinery, worker health and training, and emergencies.

## 1.2 BACKGROUND

*The Health and Safety in Employment (Mining Operations and Quarrying Operations) Regulations 2013* (the Regulations) have specific provisions for safety in mining operations, including opencast (or surface) metalliferous and coal mines. The Regulations only address competency requirements for quarrying and alluvial mining operations.

The *Health and Safety at Work Act 2015* is due to come into effect on 4 April 2016, along with new regulations (including updated mining regulations to align with the new Act and fix some drafting errors). While the law change will involve some quite significant differences (eg, how duties are framed, what injuries and incidents are notifiable, worker engagement and participation, and clearer regulations) and changes in terminology, this document will still provide sound practice guidance for ensuring health and safety in opencast mines, alluvial mines and quarries.

WorkSafe is, in consultation with the industry, updating codes of practice and guidance and producing new ones. The intent is to provide a series of documents the industry can use to comply with the new regime.

It was recognised in the Ministry of Business, Innovation and Employment's *Safe mines: Safe Workers – A quick guide for mine operators* publication that quarries would need specific health and safety guidelines.

Guidance for alluvial mines is included in this document. This is because the hazards in opencast mines are similar to those in alluvial mines, and guidance on opencast mines is provided.

## 1.3 PURPOSE

This document has been developed to assist opencast mines, quarries and alluvial mines in developing, implementing and maintaining hazard controls for common risks and to meet their obligations under the *Health and Safety in Employment Act 1992* (the HSE Act) and its associated regulations.

## 1.4 SCOPE AND APPLICATION

This document applies to opencast mines, alluvial mines and quarries. This document is mainly for operators, mine and quarry managers, employers and site health and safety representatives. However, employees, contractors, health and safety advisers, consultants and engineers may also find it helpful.

This document does not apply to underground mines or tunnels.

The precautions required in a situation will depend on the extent and nature of the risks involved. High-risk situations require higher standards of precautions than low-risk situations. Examples given do not cover every possible situation and may not be relevant to all sites. You should complete your own risk assessments and take competent advice when implementing health and safety management systems.

### 1.4.1 WHAT IS A QUARRY?

The HSE Act defines a quarrying operation as:

*(1) In this Act, quarrying operation –*

*(a) Means an activity carried out above ground for the purpose of –*

*(i) extracting any material, other than coal or any mineral, from the earth; or*

*(ii) processing any material, other than coal or any mineral, at the place where the material is extracted; and*

*(b) includes the place where an activity described in paragraph (a) is carried out; and*

*(c) Includes any place in which any material extracted or processed in a quarry is crushed or screened.*

*(2) Subsection (1) applies whether or not the material is to be extracted or processed for commercial gain and whether or not the material is extracted or processed by the use of explosives.*

Quarry operators must notify WorkSafe of the manager or acting manager of a quarry (the Regulations, Regulation 24).

If you are unsure whether your operation is a quarrying operation, as defined by section 19N of the HSE Act, you should get legal advice. For the purposes of this document, a quarry includes:

> all the surface extraction workings including preparatory and abandonment works

> tips (or dumps) associated with and in the vicinity of the site where the material is extracted, crushed or screened

> working stockpiles associated with and in the vicinity of the site where the material is extracted, crushed or screened

> settling ponds associated with and in the vicinity of the site where the material is extracted, crushed or screened

> areas used for processing extracted materials (including washing, drying and bagging), where the processing is carried out on site where the extraction is undertaken

> areas used for crushing or screening extracted or processed materials, regardless of whether it is at the place the material was extracted

> the buildings and structures at the quarry used for the working of the quarry

> common areas (eg quarry roadways and railways, but not public roads or railways under the control of a rail company)

> quarries in a forest, on a farm or on Crown or public land (eg council reserves or river beds) regardless of whether the extraction is of an intermittent nature or not.

### 1.4.2 WHAT IS NOT A QUARRY

For the purposes of this document, the following are not considered to be quarries:

> civil or building construction sites (both residential and commercial) where cut to fill is undertaken unless the construction is associated with the development of the quarry

> manufacturing that involves processing extracted material (eg hot mix or concrete) – although, a quarry's crushing or screening facility is covered, even if at a different location

> recycling aggregate plants

> stockpiles at dormant quarries and dormant river gravel extraction sites

> small scale, non-complex extraction carried out on farmland solely in support of farming (ie no tips, highwalls, explosives or processing)

> small scale, non-complex extraction carried out in forests solely in support of forestry operations (ie no tips, highwalls, explosives or processing)

> non-complex extraction of gravel from river beds where there is no mechanical processing.

### 1.4.3 WHAT IS AN ALLUVIAL MINE?

The HSE Act defines an alluvial mining operation as:

*a mining operation carried out above ground and associated with–*

*(a) The extraction of gold from river deposits of sand or gravel:*

*(b) The extraction of iron sand from sand or gravel.*

Alluvial mine operators must notify WorkSafe of the manager or acting manager of an alluvial mine (the Regulations, Regulations 24).

If you are unsure whether your operation is an alluvial mining operation as defined by section 19L of the HSE Act you should get legal advice. For the purpose of this document, an alluvial mine includes the following:

> all the surface extraction workings including preparatory and abandoned works

> tips (or dumps) associated with and close to the site where the material is extracted

> working stockpiles associated with and close to the site where the material is extracted

> settling ponds or tailing dams associated with and close to the site where the material is extracted

> areas used for the preparation of extracted materials (including crushing, screening, washing, drying, bagging and ore processing)

> the buildings and structures at the mine that are used for the working of the mine

> common areas (eg roadways and railways, but not public roads or railways under the control of a rail company).

### 1.4.4 WHAT IS AN OPENCAST MINE?

The HSE Act defines a mining operation as follows:

*In this Act, mining operation-*

*(a) Means the extraction of coal and minerals and the place at which the extraction is carried out; and*

*(b) Includes any of the following activities and the place at which they are carried out:*

*(i) Exploring for coal:*

*(ii) Mining for coal or minerals:*

*(iii) Processing coal or minerals associated with a mine:*

> *(iv) Producing or maintaining tailings, spoil heaps and waste dumps:*
>
> *(v) The excavation, removal, handling, transport and storage of coal, minerals, substances, contaminants, and wastes at the place where the activities described in subparagraphs (i) to (iv) are carried out:*
>
> *(vi) The construction, operation, maintenance, and removal of plant and buildings at the place where the activities described in subparagraphs (i) to (iv) are carried out:*
>
> *(vii) Preparatory, maintenance, and repair activities associated with the activities described in subparagraphs (i) to (iv); and*

*(c) Includes-*

> *(i) A tourist mining operation:*
>
> *(ii) A tunnelling operation; but*

*(d) Does not include-*

> *(i) Exploring for minerals:*
>
> *(ii) An alluvial mining operation:*
>
> *(iii) A mining operation wholly on or under the seabed on the seaward side of the mean high-water mark:*
>
> *(iv) A quarrying operation.*

The Regulations have definitions for two types of opencast mining operations:

> ***Opencast coal mining operation*** means any mining operation associated with the extraction of coal and where no person works underground.

> ***Opencast metalliferous mining operation*** means any mining operation associated with the extraction of minerals and where no person works underground.

In this document, these types are collectively called “opencast mines”.

You should get legal advice if you are unsure whether your operation is a mining operation or a particular type of mining operation as defined by section 19M of the HSE Act or the Regulations. For the purpose of this document, an opencast mine includes:

> all the workings when exploring for coal

> all the surface extraction workings, including preparatory and abandonment works, associated with the opencast mine

> tips (or dumps), including stockpiles, associated with the opencast mine

> settling ponds or tailing dams associated with the opencast mine

> areas used for the processing of extracted materials (including crushing, screening, washing, drying, bagging and ore processing)

> the buildings and structures at the mine that are used for the working of the mine

> common areas (eg roadways and railways, but not public roads or railways under the control of a rail company)

> an opencast tourist mining operation.

For the purpose of this document, tunnelling operations and underground mines are not considered opencast mines.

## 1.5 INTERPRETATION

The HSE Act requires duty holders to have effective ways of managing health and safety. Duty holders are not legally required to use this guidance, but it will help them to comply with the intention of the law. Alternative methods may be used, but these should be at least as safe, or better, than those set out within.

This document brings together legal obligations with other recommendations that are not legal requirements but are good practice. For the purposes of this document “must” means the instruction is a mandatory legal obligation. Should means it is recommended to be adopted where practicable.

The requirements for PHMPs and PCPs within the Regulations do not apply to alluvial mines and quarries.

## 1.6 SAFETY CRITICAL ROLES

### OPENCAST MINES

#### MINE OPERATOR

The mine operator must appoint a site senior executive (SSE) who has responsibility for managing health and safety at the operation. The SSE may be appointed to more than one mine if the mine operator is responsible for more than one operation or site. The SSE's responsibilities include appointing other safety critical roles.

#### SITE SENIOR EXECUTIVE

The SSE must hold a certificate of competence as a site senior executive. The SSE's duties include:

> developing, implementing and maintaining the HSMS at the mining operation

> making sure a risk appraisal and risk assessment process are developed and used in the HSMS

> appointing other safety critical roles.

The mine operator must provide the resources so the SSE can carry out his or her duties.

#### MINE MANAGER

A mine manager for an opencast coal mine or a mine where more than 4 workers ordinarily work at any one time must hold an A-grade certificate of competence as a mine manager. Otherwise, they must hold a B-grade certificate of competence as a mine manager. The mine manager's duties include:

> managing the mining operation

> supervising the health and safety aspects of a mining operation.

#### OTHER SAFETY CRITICAL ROLES

The SSE must appoint staff to carry out other safety critical roles including:

> ventilation officer

> electrical superintendent

> mechanical superintendent.

### QUARRYING AND ALLUVIAL MINES

Quarrying and alluvial mining operators must appoint a quarrying or alluvial mine manager, as appropriate. Their duties include:

> managing the mining operation

> supervising the health and safety aspects of a mining operation.

A quarrying manager at a site where more than four workers ordinarily work at any one time must hold an A-grade certificate of competence as a quarry manager. Otherwise, they must hold a minimum of a B-grade certificate of competence as a quarry manager.

An alluvial mine manager at a site where more than four workers ordinarily work at any one time must hold an A-grade certificate of competence as an alluvial mine manager. Otherwise, they must hold a minimum of a B-grade certificate of competence as an alluvial mine manager.

More information on what is required for a certificate of competence is available on the WorkSafe website.

PART A

# 02/

## HAZARD MANAGEMENT SYSTEM

IN THIS SECTION:


2.1 Applicable legislation: hazard management in the HSE Act and the Regulations

2.2 The health and safety management system (HSMS)

2.3 Identifying hazards and analysing risk

2.4 Risk assessment

2.5 Principal hazard management plans and principal control plans

2.6 Hazard control

2.7 Hazard monitoring

2.8 Responding to hazard reports

2.9 Accident recording, notification and investigation

**Ensuring hazards do not cause harm is the basis of health and safety in any workplace. A hazard management system is how you identify and control hazards in your workplace.**

This section describes:

> the legislative requirement to have a health and safety management system (HSMS)

> the components your HSMS needs to have

> the legislative requirement to identify hazards and manage certain hazards using a principal hazard management plan (PHMP)

> the basic concepts of hazard identification, risk assessment, and hazard management

> the legislative requirement to record and investigate accidents.

## 2.1 APPLICABLE LEGISLATION: HAZARD MANAGEMENT IN THE HSE ACT AND THE REGULATIONS

The HSE Act covers all workplaces and requires employers to take all practicable steps to ensure the health and safety of employees and others while at work. It also places health and safety duties on others, such as mine operators, principals, self-employed persons, and employees.

The Regulations have specific provisions for health and safety in mining operations. This includes opencast coal and mineral operations.

For quarrying and alluvial mining operations, the Regulations only address competency requirements. They should, however, be considered good practice.

The HSE Act refers to significant hazards and the Regulations refer to principal hazards. A significant hazard is a hazard that is an actual or potential cause or source of any of the following:

(a) Serious harm.

(b) Harm (being harm that is more than trivial) the severity of whose effects on any person depend (entirely or among other things) on the extent or frequency of the person's exposure to the hazard.

(c) Harm that does not usually occur, or usually is not easily detectable, until a significant time after exposure to the hazard.

A principal hazard is defined in Reg 65 of the Regulations. In summary, a principal hazard is any hazard that could create a risk of multiple fatalities at a mining operation, either in a single accident or in a series of recurring accidents.

All principal hazards will be significant hazards under the HSE Act. However, there are likely to be many more significant hazards than there are principal hazards.

A mining operation must have a principal hazard management plan (PHMP) for each principal hazard, and a principal control plan (PCP) where specified in the Regulations.

While alluvial mines and quarries are not legally required to determine principal hazards, WorkSafe highly recommends you follow the guidance given for principal hazards, where risks at your operation could result in multiple fatalities. For the purposes of this guidance we will describe hazards that could create a risk of multiple fatalities as principal hazards.

## 2.2 THE HEALTH AND SAFETY MANAGEMENT SYSTEM (HSMS)

Mining operations must have a HSMS, including opencast mines. WorkSafe recommends alluvial mines and quarries have a HSMS.

The HSMS is to set out a level of detail appropriate for the nature, size, complexity and hazards of the mining operation, and any other relevant matters.

Different approaches and formats may be used to develop a HSMS. Regardless of the structure adopted for the HSMS, it must include a systematic approach to hazard management and should be part of, and integrated with, the overall management system.

Where the Regulations require an HSMS to be developed, it must include:

> A health and safety policy.

> The process used to identify hazards, assess the risk of harm, and to identify controls to manage these. This could include a standard operating procedure (SOP).

> How reporting and recording health and safety information will be achieved, including setting of key performance indicators and investigation of accidents.

> A description of the systems, procedures and other risk control measures in place to manage hazards and to respond to increased levels of risks. This could include a trigger action response plan (TARP).

> How material changes that may create hazards will be identified.

> The health and safety management structure, including competency requirements and how temporary and permanent vacancies will be filled, and competency requirements for acting positions in the structure.

> Monitoring and audit matters as required by regulation 57 of the Regulations.

> How monitoring of health and safety of mine workers will be performed.

> The PHMPs and PCPs required.

> How monitoring, assessment and inspections of working places will be undertaken.

> Any other requirements of the Regulations.

For more detailed information on the content of the HSMS see regulation 56 of the Regulations. For more detailed information on developing HSMS, see the WorkSafe:

> *Guidance for a Hazard Management System for Mines.*

> *Fact Sheet: A Hazard Management System for Mining Operations.*

> *Guide to Developing Safety Management Systems for the Extractives Industry.*

Further information can also be obtained from Standards New Zealand *(AS/NZS 4804 Occupational Health and Safety Management Systems – General Guidelines on principles, systems and supporting techniques* and *AS/NZS 4801 Occupational Health and Safety Management Systems – Specification with guidance for use).*

The HSMS must be developed in consultation with workers at the site. It must be easily understood and made available to all workers.

The HSMS must be in place for:

(a) **Coal mines** – from the start of exploration activities until the abandonment of the mine.

(b) **Metalliferous mines** – from the start of physical development, including construction of mining infrastructure and earthworks, until the abandonment of the mine.

## 2.3 IDENTIFYING HAZARDS AND ANALYSING RISK

You must ensure an effective method is in place to systematically identify and regularly assess hazards to workers at your site.

Section 7 of the HSE Act outlines the process for employers to identify and assess hazards.

Regulation 54 of the Regulations outlines the process of risk appraisal for mining operations, which are additional to section 7 of the HSE Act.

Regulations 65–66 of the Regulations outlines the process for identifying principal hazards in a mining operation.

There are a number of ways to identify hazards. Some of these include:

> **Physical inspections**: inspect the workplace and assess where someone could get hurt.

> **Task and process analysis**: identify the hazards involved in each task. This should include what happens when intervention is required (eg breakdowns). Identify hazards at each stage of the production process.

> **Best practice guidelines and standards**

> **Hazard and operability study (HAZOP)**

> **Accident investigation analysis**: identify hazards and causes of harm from investigations involving similar types of work.

> **Near miss, audit or inspection analysis**: trends or common problems can be identified from near miss reports, audits or inspections. Analysis of these reports may show locations that are more dangerous and indicate problems with the design and layout of that work area or the way work is carried out there.

> **Work environment monitoring**: For example, noise assessment, air quality assessment.

> **Analytical techniques for calculating the hazard**: For example, geotechnical data for ground stability.

## 2.4 RISK ASSESSMENT

A risk assessment involves considering what could happen if someone is exposed to a hazard and the likelihood of it happening. It is part of the requirements for all workplaces under the HSE Act. The mine operator must ensure risk assessments are carried out, and the Site Senior Executive is responsible for carrying out the risk assessment.

A risk assessment can help you determine:

> how severe a risk is

> whether existing control measures are effective

> what action you should take to control it

> how urgently action needs to be taken.

Risk is a measure of the consequence and likelihood of a negative effect on the safety of people, equipment and infrastructure, or the environment. The likelihood of occurrence and consequences is generally used to estimate risk. Risk assessment can be either qualitative (ie rankings or descriptive indicators) or quantitative (ie numerical estimates).

Some hazards that have exposure standards, such as noise and airborne contaminants, may need scientific testing or measurement by a competent person. This is to accurately assess the risk and to check the relevant exposure standard is not being exceeded (eg noise meters to measure noise levels and dust deposition meters to measure airborne dust).

Similarly geotechnical or ground failure risk may be a complex issue and require a competent person for assessment.

1. Regulation 55 of the Regulations outlines the requirements for risk assessment for mining operations.
2. Regulation 82 of the Regulations outlines additional requirements for risk assessment for tips, ponds and voids.
3. Regulation 76 of the Regulations outlines additional requirements for risk assessment for work in the inrush control zone.
4. Regulation 80 of the Regulations outlines additional requirements for risk assessment for roads and other vehicle operating areas.

5. Regulation 105 of the Regulations outlines additional requirements for risk assessment for emergency management planning.

More detailed information on risk assessment is available in:

> *AS/NZ 4804 Occupational Health and Safety Management System – General guidelines on principles, systems and supporting techniques Section 4.3.4.*

> *AS/NZS ISO 31000 Risk Management – Principles and Guidelines.*

> *MDG 1010 Minerals Industry Safety and Health Risk Management Guideline.*

## 2.5 PRINCIPAL HAZARD MANAGEMENT PLANS AND PRINCIPAL CONTROL PLANS

A principal hazard is one that could cause multiple fatalities, either in a single accident or in a series of recurring accidents. The Regulations list some things to that may cause principal hazards, but is not exhaustive.

### 2.5.1 PRINCIPAL HAZARD MANAGEMENT PLANS (PHMP)

A PHMP sets out the measures that will be used to manage a particular principal hazard. A PHMP must be in writing and include:

> the nature of the principal hazard

> the roles, responsibilities and competencies required to implement the PHMP

> any other matter required by the Regulations in relation to particular principal hazards.

It must also include a description of:

> how risk assessments will be conducted and the result of any completed

> the control measures to be implemented to manage it and the risk of harm it presents

> how any specific requirements in the regulations (if any) will be complied with

> emergency preparedness for the principal hazard

> the review and audit processes for the PHMP.

See the Regulations for the full requirements, including requirements specific to each PHMP.

A PHMP is required for each principal hazard regardless of the likelihood of an accident.

A PHMP should show the risk, after controls and monitoring, is reduced by "all practicable steps" as per the HSE Act.

If a particular principal hazard is not present, a PHMP will not be required for it. A PHMP is still required for mining operations where:

> explosives are used

> a tip is located on a slope, and is greater than 15 meters in height and 100,000 $m^3$ in volume.

### 2.5.2 PRINCIPAL CONTROL PLANS (PCP)

The purpose of a PCP is to link the duties and functions of the people, the equipment and the environment in which they operate. Some control measures may be used to control the risks associated with more than one hazard. This may include principal hazards and significant hazards. These can be put together as a PCP which will set controls for the whole mine. The PCP must explain the control measures to be taken.

A PCP will not necessarily provide all the controls for a particular hazard. For example, the controls needed for a principal hazard may be provided by one or more PCPs, plus specific controls in a PHMP.

A PCP should show the risk, after controls and monitoring, is reduced by "all practicable steps" as per the HSE Act.

Not all PCPs are required for all mining operations and you will need to refer to the Regulations for specific details.

The following is a list of PCPs that may be required for opencast mines:

> mechanical engineering

> electrical engineering

> emergency management

> worker health.

Although not required by the Regulations, WorkSafe recommends that surveying requirements should be covered by a PCP.

## 2.6 HAZARD CONTROL

The ways of controlling hazards are ranked from the highest level of protection and reliability to the lowest as shown in Figure 1. This is known as the hierarchy of control. Sections 8–10 of the HSE Act require employers to work through this hierarchy when managing significant hazards (which includes principal hazards).

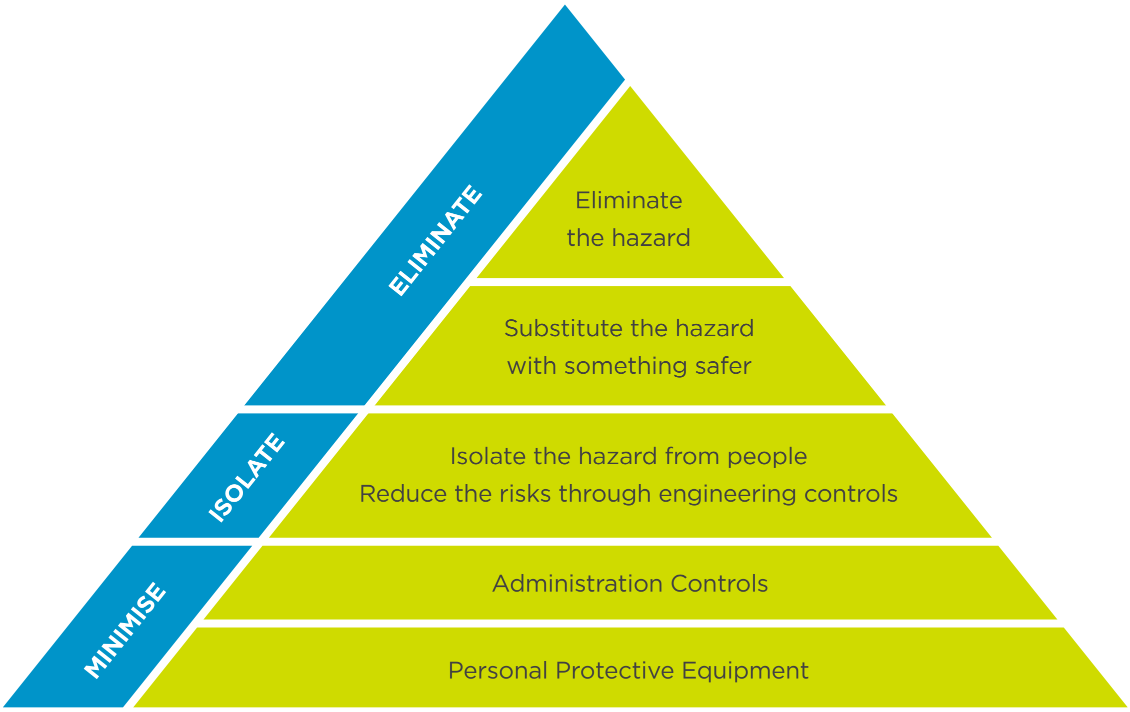



**Figure 1:** Hierarchy of controls

### LEVEL 1 CONTROL METHODS – ELIMINATION

The most effective control measure is to eliminate the hazard and associated risk. You must always aim to eliminate a hazard, where reasonably practicable. The best way to do this is by not introducing the hazard into the workplace. For example, you can eliminate the risk of a fall by doing the work at ground level.

Eliminating hazards is often cheaper and more practical to achieve at the design or planning stage. In these early stages, there is greater scope to design out hazards or incorporate risk control measures that are compatible with the original design and functional requirements. For example, a noisy machine could be designed and built to produce as little noise as possible, which is more effective than providing workers with personal hearing protectors.

You can eliminate risks by removing the hazard completely; for example, by removing trip hazards on the floor or disposing of unwanted chemicals.

It may not be possible to eliminate a hazard if doing so means that you cannot make the end product or deliver the service. If you cannot eliminate the hazard, then eliminate as many of the risks associated with the hazard as practicable. This may include substituting the hazard with something safer; for example replacing solvent-based paints with water-based ones.

#### LEVEL 2 CONTROL MEASURES – ISOLATION

If it is not reasonably practicable to eliminate a hazard and associated risk, you must reduce the risk by isolating people from the hazard. This involves physically separating the source of harm from people by distance or using barriers. For example, you could install guard rails around exposed edges and holes in floors, use remote control systems to operate machinery, or store chemicals in a fume cabinet.

Isolation controls can include engineering controls. Engineering controls are physical in nature, including a mechanical device or process. For example, you could use mechanical devices such as trolleys or hoists to move heavy loads, place guards around moving parts of machinery, install residual current devices (electrical safety switches) and so on.

#### LEVEL 3 CONTROL MEASURES – MINIMISATION

Minimisation control measures do not control the hazard at the source. They rely on human behaviour and supervision, and used on their own, tend to be least effective in minimising risks. Two approaches to reduce risk in this way are:

> Administrative controls: work methods or procedures that are designed to minimise exposure to a hazard; for example, developing procedures on how to operate machinery safely, limiting exposure time to a hazardous task, using signs to warn people of a hazard.

> Using Personal Protective Equipment (PPE): for example, ear muffs, respirators, face masks, hard hats, gloves, and safety glasses. PPE limits exposure to the harmful effects of a hazard, but only if workers wear and use the PPE correctly.

Only use administrative controls and PPE:

> where no other practicable controls are available (as a last resort)

> as an interim measure until a more effective control can be used

> to supplement higher level controls (as a back-up).

When a significant hazard can only be minimised, section 10 of the HSE Act requires employers to monitor employees' exposure to the hazard and monitor their health. Employers must take all practicable steps to get their employees informed consent to conduct this health monitoring. They can only perform monitoring with this informed consent.

With changes in technology and cost of controls over time, methods to eliminate and isolate a hazard may become practicable. You must continue to assess significant hazards that are being minimised to determine whether other methods are available to control them. For example, replace or upgrade older vehicles with ones with better safety devices such as anti-lock brakes, traction control and retarders.

## 2.7 HAZARD MONITORING

You must regularly review your operations to identify any new hazards that may have arisen. You must also review the controls you have in place to ensure the controls are still effective.

In addition to your duties under the HSE Act, mine operators, mining operations and SSE's have other responsibilities under the Regulations to audit and review hazard controls.

Regulations 57–59, 69, 70, 75, 82, 89, 94, 95 of the Regulations outline the process of review and auditing for mining operations.

## 2.8 RESPONDING TO HAZARD REPORTS

Mine operators must ensure hazards reported by mine workers are investigated. This must be completed as soon as practicable, with regard to the seriousness of the hazard (see the box below).

**Regulation 115 Mine operator must investigate reported hazard**

(1) If a mine worker reports the existence of a hazard in the mining operation, including (without limitation) any action done or not done in contravention of any system, procedure, or other risk-control measure in place at the mining operation to control a hazard, the mine operator must ensure that the report is investigated.

(2) The investigation must be completed as soon as practicable, having regard to the seriousness of the hazard.

**Regulation 116 Mine operator must advise mine worker of result of investigation**

When the investigation required by regulation 115 is completed, the mine operator must ensure that the mine worker who reported the hazard is promptly advised of the result of the investigation.

Hazard notices may be issued by trained site health and safety representatives in accordance with section 19ZF of the HSE Act.

## 2.9 ACCIDENT RECORDING, NOTIFICATION AND INVESTIGATION

Section 25 of the HSE Act outlines your duties regarding accident recording and notification. In summary you must:

> maintain a register of accidents and serious harm

> notify WorkSafe as soon as possible if serious harm or any of the accidents described in regulations occur

> give WorkSafe written notice of the accident and the circumstances it occurred in.

The register of accidents must include accidents that might have harmed (eg near miss incidents).

Mine operators have additional duties described in the box below.

**Regulation 226 Register of accidents and serious harm**

(1) The mine operator must record the particulars of the following in relation to any mine worker:

  (a) every accident that harmed (or, as the case may be, might have harmed) the mine worker at the mining operation; and

  (b) every occurrence of serious harm to the mine worker at work, or as a result of any hazard to which the mine workers was exposed while at the mining operation.

(2) For each accident or occurrence of serious harm, the particulars prescribed in Schedule 7 must be recorded in a register of accident and serious harm maintained by the mine operator.

(3) The mine operator must ensure that a copy of the register is provided to WorkSafe at intervals of not more than 6 months.

(4) For the avoidance of doubt, a mine operator is not required, in relation to any mine worker, to maintain a separate register of accidents and serious harm under section 25(1) or (1B) of the Act.

**Regulation 227 Notification of accidents and serious harm**

(1) For the purpose of section 25(2)(b) of the Act, every accident specified in Schedule 8 is required to be notified to WorkSafe if the accident occurs at a mining operation.

(2) For the purpose of section 25(3)(b) of the Act, the mine operator must notify the following to WorkSafe:
  (a) Every accident specified in Schedule 8 if the accident occurs at the mining operation; and
  (b) Every occurrence of serious harm at the mining operation.

(3) The mine operator must notify the accident or serious harm to WorkSafe by providing the particulars prescribed in Schedule 7 to WorkSafe.

(4) The mine operator must also provide the particulars of the accident or serious harm, except for personal information about any mine worker, to every site health and safety representative at the mining operation.

(5) WorkSafe must make the particulars of the accident or serious harm, except for personal information about any mine worker, available to industry health and safety representatives.

(6) For the avoidance of doubt, a mine operator is not required, in relation to any mine worker, to separately notify the accident or serious harm to WorkSafe on the basis that the mine worker is an employee of a self-employed person contracted to the mine operator.

The HSE Act requires employers to investigate accidents or harm that have been recorded in the accident register (as per section 25 of the HSE Act) whether or not it was caused by or arose from a significant hazard. The Regulations place additional duties on mine operators to investigate accidents.

Accident investigations should identify controls to prevent the same or similar incidents reoccurring.

Employers must investigate any accidents or harm to determine whether a significant hazard was involved[1].

**Regulation 228 Accident Investigation**

(1) The mine operator must ensure that-
  (a) any accident at the mining operation is investigated; and
  (b) the investigation findings are made available to the mine workers at the mining operation.

(2) If the accident is a notifiable accident, the mine operator must ensure that a report of the investigation findings is provided to WorkSafe within 30 days of the date on which the accident occurred.

(3) A procedure for making findings available to workers must be included in the health and safety management system.

(4) Nothing in this regulation affects section 7(2) of the Act.

### 2.9.1 OTHER NOTIFICATIONS

Mining operations must notify WorkSafe of a number of matters, including:

> the commencement, recommencement, installation or cessation of the operation
> the proposed date of installation of:
  – a shaft
  – a winding system
> the appointment of
  – an SSE
  – an acting SSE
  – a mine manager
  – acting mine manager
> any of the notifiable accidents set out in Schedule 8 of the Regulations
> any of the high-risk activities set out in Schedule 9 of the Regulations.

[1] The *HSE Act*, section 7

Mine operators also have obligations to submit draft PHMPs and PCPs to WorkSafe.

Quarries and alluvial mines must notify WorkSafe about the nature of the operation, its location, and the name of the relevant manager for the operation. The zone of operation for mobile crushing plant operating over an area should be notified to Worksafe, along with the details for the relevant manager.

More details of what must be notified, as well as the contact details, and notification form, are available under the Extractives section of the WorkSafe website.

## 2.10 HAZARDOUS SUBSTANCES

Many chemicals and fuels used in extractive operations are hazardous and are controlled under the Hazardous Substances and New Organisms Act 1996 (HSNO).

Hazardous substances used in the extractive industry include:

> explosives and detonators
> compressed gases
> petrol, diesel and liquefied petroleum gas (LPG).

### 2.10.1 HAZARD CLASSIFICATIONS, APPROVALS AND CONTROLS

Hazardous substances are classified according to their hazardous properties. Hazardous substances may have one or more the following properties:

> explosive – hazard class 1
> flammable – hazard classes 2, 3 and 4
> oxidising – hazard class 5
> toxic – hazard class 6
> corrosive – hazard class 8
> toxic to the environment (ecotoxic) – hazard class 9.

All hazardous substances must be approved by the Environmental Protection Authority (EPA) under HSNO. An approval lists the controls, or rules, that apply to the substance so that the risks to people and the environment are safely managed.

Controls cover:

> packaging and labelling
> information about hazardous substances – safety data sheets
> protective clothing and equipment
> safe storage of hazardous substances including:
  – warning signs
  – container types
  – storage location and construction
  – certification of storage locations and containers
> training and certification for people who use hazardous substances, including approved handler certification and controlled substance licenses
> tracking the most hazardous substances, including explosives
> emergencies including:
  – fire extinguishing
  – spill and leak control
  – planning for emergencies.

### 2.10.2 PERSON IN CHARGE

HSNO requires a person in charge at all workplaces to manage hazardous substances. They must make sure that the HSNO controls are complied with.

### 2.10.3 STAYING SAFE WITH HAZARDOUS SUBSTANCES – WHERE TO START

You need to know what hazardous substances you have and how to manage them. Product labels and safety data sheets (SDSs) provide information about the product's hazards and how to manage them. Manufacturers and suppliers must only sell correctly labelled substances and must provide compliant and up to date SDSs for hazardous substances.

SDSs contain important information about:

> first aid
> storage
> cleaning up spills
> the right protective equipment.

Make sure you have SDSs for all your hazardous substances. Contact your supplier who must provide them.

Which controls you have to follow depends on the type and amounts of hazardous substances you have. Make a list, or inventory, of all the hazardous substances you have, the amounts you have, their hazards and approval numbers. The approval number should be on the SDS. You can use the information in your inventory on the *HSNO Calculator* (www.hazardoussubstances.govt.nz) and the *Approved Hazardous Substances with Controls Database* with on the Environmental Protection Authority website (www.epa.govt.nz).

#### 2.10.4 WHERE TO GET MORE INFORMATION

The Hazardous Substances website (www.hazardoussubstances.govt.nz) provides information on hazardous substances and controls. It also has the HSNO calculator.

The Environmental Protection Authority's website (www.epa.govt.nz) contains information about hazardous substance approvals.

PART

# B

# Planning and design

This part of the guide provides guidance for designing safety into mine and quarry operations. It describes in detail how to plan excavations, tips, ponds, dams, roads, and vehicle operating areas.

PART B

# 03/

# PLANNING FOR EXCAVATION

## IN THIS SECTION:


3.1 Terminology

3.2 Appraisal of ground or strata instability principal hazard

3.3 Ground or strata instability principal hazard management plan (PHMP)

3.4 Geotechnical assessment

3.5 Slope design

3.6 Ground support and reinforcement systems

**Planning for excavations requires a good understanding of ground conditions, and determining ways in which potential ground failure could be avoided. A systematic approach to managing ground instability is very important.**

This section describes:

> how to identify and manage hazards from unstable ground
> the role of geotechnical assessments
> how to design safe slopes
> how to stabilise and support slopes.

The potential impacts of unplanned and uncontrolled ground movement are:

> Safety – Loss of life or injury to those working at or visiting the site.
> Social – Loss of income and workforce confidence, minimised corporate credibility, and increased liability.
> Financial and economic – Disruptions to operations, product or equipment losses, increased stripping and clean-up costs, and reduced access to markets.
> Environmental – Collapse of or damage to nearby infrastructure, interference with natural drainage and damage to surrounding land, natural habitats, wildlife or conservation initiatives and programmes.

Safely developing a mine or quarry requires assessment of the deposit and the factors that will affect ground stability including:

> the dip and strike
> bedding planes
> faulting
> folding
> other geological characteristics.

A systematic approach to ground stability requires a good understanding of ground conditions before operations start. Slope designs should be suitable for the ground conditions and, where necessary, include the design and implementation of ground support or reinforcement. The ongoing maintenance of supports and continuous monitoring for any indication of movement or potential for failure are also important components of a systematic approach.

Refer to Section 7 for more information on controlling ground stability.

## 3.1 TERMINOLOGY

Slopes are generally designed as a series of batters separated by benches, which are provided at predefined vertical height intervals (see Figure 2).

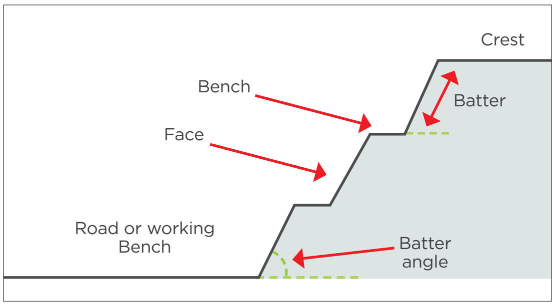



**Figure 2:** Slope design terminology

Access to an excavation can be by a road or ramp that may spiral around, or be located on one side of the excavation with switchbacks at each end. A succession of batters between two access ramp sections (or between a ramp section and the floor or crest) is defined as the inter-ramp slope. The inter-ramp slope angle is always flatter than the batter angle in that slope. The full height of a slope, from the toe to the crest, comprising several batters separated by benches (and access road sections if the road is on that slope) is the overall slope (see Figure 3).

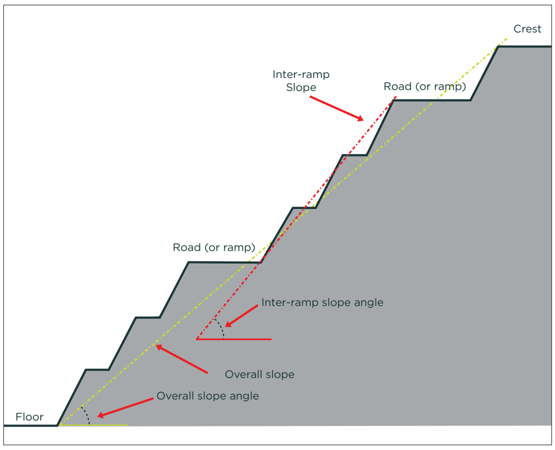



**Figure 3:** Slope design – inter-ramp and overall slope details

## 3.2 APPRAISAL OF GROUND OR STRATA INSTABILITY PRINCIPAL HAZARD

Excavation faces and ponds should be properly designed, with:

> stable slope angles
> adequate benches
> bench widths at least half the face height, and not less than 3.5 m
> face heights suitable for the site conditions and excavation method
> faces that do not exceed the reach of the excavator
> faces scaled to control the risk of rock falls
> faces, at quarries, and working benches in alluvial mines, that have not been undermined.

The SSE must carry out an appraisal of the mining operation to identify principal hazards at the mining operation[2].

Use competent people for technical input and advice during the appraisal process, as required.

To determine if ground or strata instability is a principal hazard, consider how an excavation might feasibly fail, and the likely consequences of any such failure. The probability of such a failure actually happening is not relevant in this context. The consequences depend on the likely scale of the failure (that is, the size of the failure and the area affected by it) and whether people are likely to be fatally injured.

For other surface operations (ie quarries and alluvials) an appraisal of the operation must also be done by a competent person to determine whether a geotechnical assessment is required.

As a guide:

> Simple operations (eg shallow depth, soft material with faces less than 3.5 m, or competent rock with faces less than 15 m) require a *geotechnical appraisal* by a competent person to determine that the face design is safe, adequate benching is in place, and confirm to the operator that a geotechnical assessment is not required. Assessments should be in writing, dated and signed with a review period established.
> Complex operations (eg individual faces exceeding 15 m, overall excavation depth exceeding 30 m, fractured rock, disturbed geological structure) require a *geotechnical assessment* by a competent person.

A geotechnical assessment should be completed where:

> The height of any individual face is more than 15 m.
> In the case of 'soils and very weak rock' where the height of any part of an excavation is more than 3.5 metres and the overall slope angle is steeper than 2 horizontal to 1 vertical (27° to the horizontal) (see Figure 4).
> The bottom of the excavation is more than 30 metres below any surrounding land within 30 metres of the edge of the excavation (that is, the excavation is more than 30 metres deep, allowing for any nearby higher ground) (see Figure 5).

[2] *Health and Safety in Employment (Mining and Quarrying) Regulations 2013*, regulation 66 (1) (a)

> Irrespective of the excavation face height, depth or angle there are factors that mean there could be a principal hazard. An example could be fractured rock mass or geological discontinuities (poor rock mass quality) or the location or proximity of a tip.

> In the case of 'stronger rock', and well-cemented gravels, a geotechnical assessment should be carried out where the overall:

- height of any adequately benched slope, from toe to crest, is between 15 m–30 m
- slope angle is steeper than one horizontal to one vertical (45° to the horizontal) (see Figure 5).

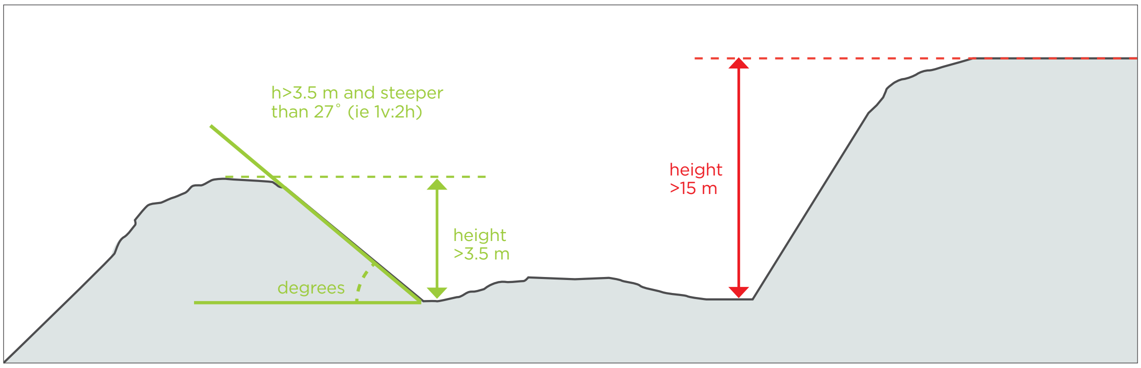



**Figure 4:** 'Soils and very weak rock' guidance

Following the identification of ground or strata instability as a principal hazard, the SSE must ensure a geotechnical assessment is completed by a competent person. This must determine the level of ground or strata support required to safely conduct the mining operation[3].

A risk assessment must be completed for the ground or strata instability principal hazard. A description of how the risk assessment will be conducted and the results of the risk assessment must be included in the PHMP[4].

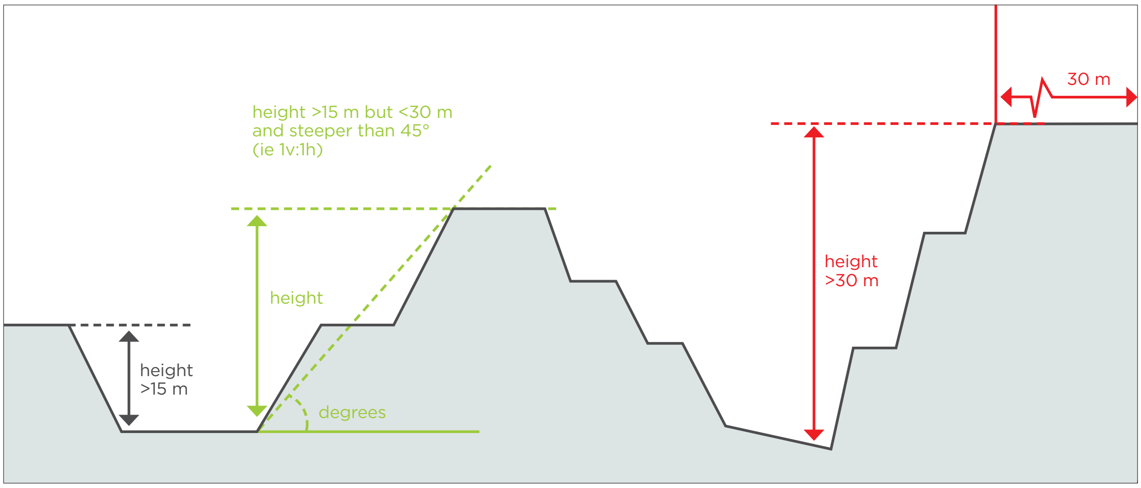



**Figure 5:** 'Stronger rock' guidance

[3] The Regulations, regulation 71 (1)
[4] The Regulations, regulations 68 (b) and (c)

The definition of 'soils and very weak rock' and 'stronger rock' is provided in Table 1 below.

<table>
<tr><th>TERM</th><th>DEFINITION</th></tr>
<tr><td>Soils and very weak rock</td><td>As defined by the NZ Geotechnical Society Incorporated Field Description of Soil Analysis Guideline (Dec 2005) Table 3.5 Rock Strength Terms being:
<table>
<tr><th>Term</th><th>Field identification of specimen</th><th>Unconfined uniaxial compressive strength $q_u$ (MPa)</th><th>Point load strength $I_{s(50)}$ (MPa)</th></tr>
<tr><td>Very weak</td><td>Crumbles under firm blows with point of geological hammer. Can be peeled by a pocket knife</td><td>1 – 5</td><td rowspan="2"><1</td></tr>
<tr><td>Extremely weak (also needs additional description in soil terminology)</td><td>Indented by thumb nail or other lesser strength terms used for soils</td><td><1</td></tr>
<tr><td colspan="4">Note: No correlation is implied between $q_u$ and $I_{s(50)}$</td></tr>
</table>
</td></tr>
<tr><td>Stronger rock</td><td>As defined by the NZ Geotechnical Society Incorporated Field Description of Soil Analysis Guideline (Dec 2005) Table 3.5 Rock Strength Terms being:
<table>
<tr><th>Term</th><th>Field identification of specimen</th><th>Unconfined uniaxial compressive strength $q_u$ (MPa)</th><th>Point load strength $I_{s(50)}$ (MPa)</th></tr>
<tr><td>Extremely strong</td><td>Can only be chipped with geological hammer</td><td>>250</td><td>>10</td></tr>
<tr><td>Very strong</td><td>Requires many blows of geological hammer to break it</td><td>100 – 250</td><td>5 – 10</td></tr>
<tr><td>Strong</td><td>Requires more than one blow of geological hammer to fracture it</td><td>50 – 100</td><td>2 – 5</td></tr>
<tr><td>Moderately strong</td><td>Cannot be scraped or peeled with a pocket knife. Can be fractured with single firm blow of geological hammer</td><td>20 – 50</td><td>1 – 2</td></tr>
<tr><td>Weak</td><td>Can be peeled by a pocket knife with difficulty. Shallow indentations made by firm blow with point of geological hammer</td><td>5 – 20</td><td><1</td></tr>
<tr><td colspan="4">Note: No correlation is implied between $q_u$ and $I_{s(50)}$</td></tr>
</table>
</td></tr>
</table>

**Table 1:** Definition of very weak rock or soils and weak rock or stronger rock

Table 2 shows questions that could be considered during a risk assessment completed in respect of ground instability.

| PARAMETER | CONSIDERATIONS |
|---|---|
| **Slope type** | Active or inactive |
| **Slope geometry** | Overall slope height, slope angle, bench height, bench slope angle, bench width |
| **Slope material characteristics (including alteration grade)** | Rock or soil, structurally controlled, variable alteration or materials present, material or discontinuity shear strength parameters |
| **Proximity of existing structures** | Property or services adjacent to both crest and toe of slope, both external and located on site |
| **Proximity of workers** | Vulnerability, location relative to potential failure |
| **Proximity of general public** | Proximity of public access, roads, footpaths, walkways and so on |
| **Failure mechanism** | Rockfall, planar, wedge, toppling, rotational, flow, travel distance |
| **Speed of failure** | Rapid (flows, rockfall), slow (rotational), very slow (rotational) |
| **Water (surface water and groundwater)** | Visible signs of seepage or discharge, prevention of detrimental effects by effective surface water management |
| **Past history of failure** | History of instability (type, location and so on), visible signs of active or previous failure (bulging of slope surfaces and so on) |
| **Existing remedial measures** | Bolting, regrading, pumping (de-watering) |
| **Monitoring** | Extensometers, piezometers, closure meters, EDM targets, radar |
| **Seismic history** | Whether the region is seismically active |
| **Operating parameters** | Exposure time of workers (shift), excavation method, associated equipment (vehicle) exposure, effects of poor blasting |

**Table 2:** Key questions for risk assessment

## 3.3 GROUND OR STRATA INSTABILITY PRINCIPAL HAZARD MANAGEMENT PLAN (PHMP)

Where an appraisal has identified a principal hazard, the SSE must ensure there is a PHMP for the principal hazard[5].

The ground or strata instability PHMP must contain information detailed in regulations 68 and 71 of the Regulations. In summary, regulation 71 requires the PHMP to include:

> when and how ground failure may occur and how it can be avoided
> suitable ground control methods, including continuous modelling, testing and updating
> appropriate equipment and procedures for monitoring, recording, interpreting and analysing data about seismic activity
> collection, analysis and interpretation of relevant geotechnical data

[5] The Regulations, regulation 66 (1) (b)

> how to maintain ground support integrity including replacement of defective supports
> allowance for higher standards of support to be installed than that required by the PHMP.

The ground or strata instability PHMP should be developed in the context of the whole HSMS and not in isolation. This will ensure gaps and overlaps are identified and used in the implementing of suitable controls for ground or strata instability.

For more detailed information on the content of the PHMP, and its relationship with other management and controls plans, processes and procedures see WorkSafe's *Guidance for a Hazard Management System for Mines* and *Developing a Ground or Strata Instability Principal Hazard Management Plan.*

## 3.4 GEOTECHNICAL ASSESSMENT

Geotechnical assessments must be carried out by a competent person.

Geotechnical assessment of ground conditions is critical to developing a comprehensive PHMP, where applicable. The data collected during the geotechnical assessment underpins:

> slope design and its stability
> the implementation of a suitable support system (where required)
> the ongoing monitoring requirements suitable to the size and scale of the design.

The geotechnical assessment will provide an indication of the risk of failure of a particular slope. This normally involves application of a factor of safety calculation but may include more extensive probabilistic analysis. For more detailed information on factor of safety (FOS) and probability of failure (POF), see section 3.5.1.

The geotechnical assessment may include:

> field data collection
> formulation of a geotechnical model
> slope design
> design, control and monitoring of blasting
> design, installation and quality control of rock support
> design of suitable monitoring systems.

Factors that may be considered during the geotechnical assessment include:

> possible seismic (either natural or induced) or geothermal activity
> previously excavated or abandoned workings
> subsidence or settlement (either controlled or through strain)
> drainage patterns, groundwater regimes, water inflow and dewatering procedures
> equipment and procedures used for scaling
> effect of time and oxidation on rock support and stability.

### 3.4.1 FIELD DATA COLLECTION

Field data collection is the process of obtaining relevant information which might affect the design, construction and performance of excavations.

The information collected could include:

> site history
> topography and geomorphology
> local climate
> hydrogeology and drainage
> physical geology and geologic structure
> lithology and rock mass properties.

Data collection should always be carried out by a competent person (ie a geologist, engineering geologist or geotechnical engineer) or a properly trained geotechnician under the supervision of an engineering geologist or geotechnical engineer.

More information on field data collection can be found in Appendix C: Field Data Collection.

#### 3.4.2 FORMULATION OF A GEOTECHNICAL MODEL

The geotechnical assessment should address or include:

> An assessment of the geological features of the deposit, including
  - the strength of the rock mass,
  - hydrogeology,
  - the orientation of geological structure,
  - external influences.
> The design of bench heights and bench widths, taking into account excavation method and equipment.
> How to orient the quarry faces to stability for blasting and excavation, including consideration of failure modes and how they will be managed.
> An assessment of the suitability of the design for short and long-term stability and maintenance of the faces.
> An indication of the probability of failure or the factor of safety of the overall excavation.
> The inspection and monitoring requirements.
> The design must also allow adequate space for haul roads with provision for safety features as necessary, ie
  - suitable road widths, with
  - inner rock trap and berm,
  - outer edge protection (ie windrow) and
  - face edge stand-off.

## 3.5 SLOPE DESIGN

At mines or quarries there is a tendency to increase the slope angle to decrease waste rock stripping and possibly generate higher return on investment. However, increasing the slope angle decreases the stability of the slope. This could lead to safety implications and higher operating costs due to slope failures.

By applying sound geotechnical engineering practices, safe slopes can be designed and maintained in almost any geological environment.

Varying parameters of bench height, bench width, batter face angle, and inter-ramp slope height and slope angle all contribute to improve overall slope stability. Examples of each are provided below.

#### 3.5.1 SLOPE STABILITY ANALYSIS AND FACTOR OF SAFETY (FOS)

Fundamental to slope stability analysis are the anticipated modes of failure, the scale of the slope, available data and the perceived risk relevant to the particular stage of the slope.

Whether a particular failure is 'acceptable' will depend on its consequence and risk. If the failure of a particular slope has no bearing on its surroundings or safety and production, it is likely to be of minimal concern. However, this is generally not the case. As such, slopes need to be designed to an acceptable standard taking into account the consequence of failure and the inherent uncertainty in the geotechnical model.

Slope design is essentially governed by two factors, the consequence of failure and the degree of inherent uncertainty. It is usual practice to apply a FOS or POF to the design geometry. When the consequence of failure or the level of uncertainty is high, the design criteria should be altered accordingly (resulting in a more conservative design). An example of the FOS and POF design criteria approach is shown in Table 3.

| WALL CLASS | CONSEQUENCE OF FAILURE | DESIGN FOS | DESIGN POF | EXAMPLES |
|---|---|---|---|---|
| 1 | Moderately serious | 1.2 | 10% | Highwalls not carrying major infrastructure |
| 2 | Serious | 1.5 | 1% | Highwalls carrying major infrastructure (eg treatment plant, ROM pad, tailings structures, crushing structures) |
| 3 | Serious* | 2.0 | 0.3% | Permanent highwalls near public infrastructure and adjoining leases |

Source: Safe Work Australia Ground Control in Open Pit Mines (July 2011)

**Table 3:** Example of FOS and POF design criteria approach

## TYPES OF ANALYSIS

When developing stability analysis criteria it is critical to have an understanding of the origins and limitations of the various geotechnical engineering design procedures when applying them.

Further information on the following types of analysis can be found in Appendix E: Types of Analysis:

> rock mass rating (RMR) and mining rock mass rating (MRMR) Classification Systems

> kinematic analysis of structurally controlled failures

> limit equilibrium analysis

> numerical analysis.

## MODES OF FAILURE

Collecting and interpreting information on major structures and other geological features is important in determining failure potential.

Steeper and higher slopes or batters will generate greater driving forces. This increases the potential for rock mass failure, presenting a higher risk. Slopes or batters excavated within rock masses that contain persistent geological structures have greater potential to develop large wall-scale failures.

Control of large failures is generally more difficult and important than small failures.

This section contains information on dams as well as the tips, ponds and voids principal hazard. This is because dams are often covered by this PHMP, particularly with tailings dams. Potential large scale failures are usually controlled by:

> excavating slopes or batters to a shallower angle

> depressurisation of groundwater in the rock mass

> installing ground support and reinforcement.

Using ground support and reinforcement to control large scale failures is generally more costly than when used for discontinuities with shorter trace lengths.

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* Where a mutually acceptable agreement to allow excavation cannot be made between the quarry or mine owner and the "owner" of the adjoining structure or plot of land. Note a higher standard of geotechnical data is required for the design of category 3 slopes compared to category 1 and 2 slopes

Basic modes of failure are listed below (Girard J.M. 2012).

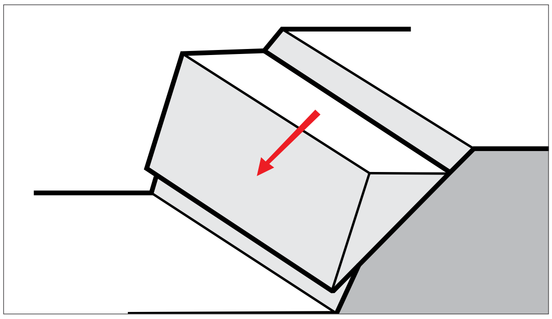


**Figure 6:** Planar failure

**Planar failures** occur when a geological discontinuity, such as a bedding plane, strikes parallel to the slope face and dips into the excavation at an angle steeper than the angle of friction.

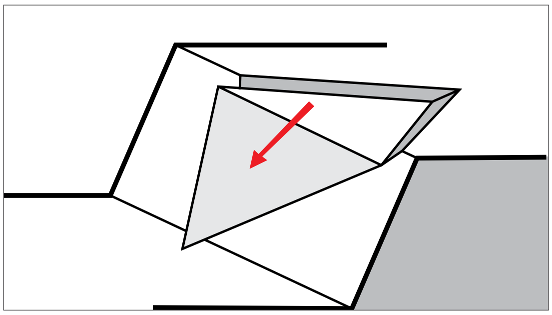


**Figure 7:** Wedge failure

**Wedge failures** occur when two discontinuities intersect and their line of intersection daylights in the face.

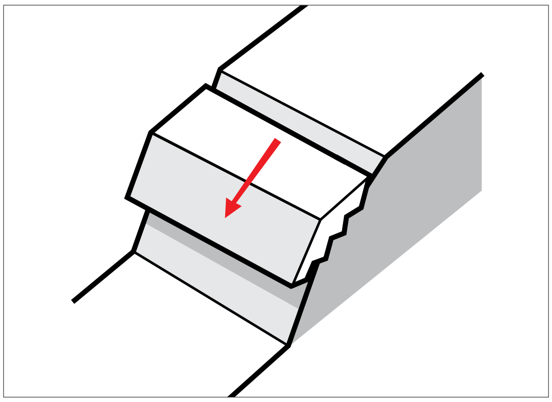


**Figure 8:** Step-path failure

**Step-path failure** is similar to planar failure, but the sliding is due to the combined mechanisms of multiple discontinuities or the tensile failure of the intact rock connecting members of the master joint set.

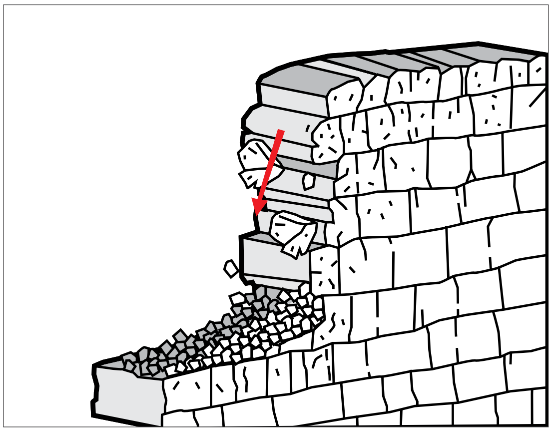


**Figure 9:** Ravelling failure

**Ravelling:** Weathering of material and expansion and contraction associated with freeze-thaw cycles are the main causes of ravelling. This type of failure generally produces small rock falls, not massive failures.

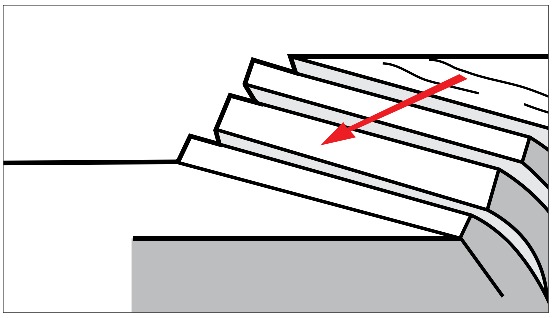


**Figure 10:** Toppling failure

**Toppling** can occur when vertical or near-vertical structures dip toward the pit. In this case, the bench face height should be limited to a distance roughly equal to the bench width. This will help catch any toppling material and decreases the chances of impacting work on the pit floor.

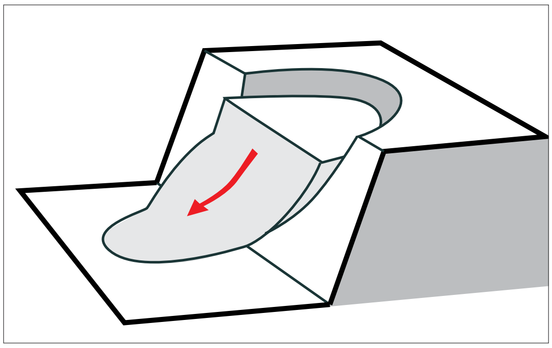


**Figure 11:** Circular failure

**Circular failures** (or slumps) generally occur in weak rock or soil slopes. They do not necessarily occur along a purely circular arc, but some form of curved failure surface is normally apparent. Failures can occur at the surface (slope failure), at the toe (toe failure), or at depth in a weak zone.

### 3.5.2 BATTER AND FINAL BENCH DESIGN

Slopes are generally designed as a series of batters separated by benches, at predefined height intervals.

Benches should be wide enough to stop potentially hazardous rock falls and contain any spills from the batters above.

The final decision on the maximum batter height should be based on:

> reliability of the batter slope (ie stability under potential failure modes)
> availability of equipment for adequate scaling to remove loose pieces of rock.

For reliability of the batter design, all possible failure modes should be identified and their stability assessed by kinematic and limit equilibrium analyses, as appropriate.

Further information about batter and bench design can be found in Appendix F: Batters and final bench design, including information on:

> batter height and reach
> final bench spacing
> final bench widths.

### 3.5.3 OVERALL SLOPE DESIGN

The methods of analysis required for overall slope design are the same as those used for the batter design, except the scale is different. In stronger rocks, overall slopes may fail by planar and wedge sliding. In soils and weak rocks, they may fail by toppling and rotational shearing. More complex collapses involving failure through the rock mass will require analysis by numerical methods.

Batter stability immediately below and above the access ramp should also be considered when designing inter-ramp slopes. Batter instability immediately below could undermine the ramp and instability immediately above could spill onto the ramp.

### 3.5.4 WORKING BENCH WIDTHS

To determine working bench widths, consider the type of equipment and the method of mining or quarrying. You should ensure there is enough room to allow the:

> cordoning off of unsafe ground conditions that may occur
> roadway to be located away from the face
> excavating mobile plant to work
> correct positioning of trucks being loaded
> safe queuing of trucks while waiting to be loaded.

People should not be allowed to work near or under hazardous faces or banks. Unsafe ground conditions should be corrected promptly, or the area cordoned off.

### 3.5.5 GROUNDWATER AND SURFACE WATER CONTROL

Mines or quarries excavated below the ground water table may need some form of dewatering and depressurisation. The most significant related problem is the effect that water pressure has on the stability of the slopes. Water pressure in structural defects in the rock mass, and pore spaces in rock material reduces effective stress, and consequently shear strength.

At some sites, with minor ground water inflow from slopes or floor, evaporation alone can account for all dewatering requirements. At other sites, major pumping operations may be necessary. The approach to ground water control can be by means of water abstraction methods such as:

> using production bores
> through sumps or trenches
> through sub-horizontal drainage holes drilled into the slopes.

Each method can be used individually or in combination to produce the required result. Selection of the most appropriate method will depend largely on the local and regional hydrogeological conditions, the relative importance of depressurisation to the specified design and the required rate of production. At large extractive sites, all three methods may be required for groundwater control. The production bores can be used in advance of and during extraction.

Control of surface drainage is also an important aspect of the implementation of the slope design. Surface water drainage paths through and around the site should be designed, constructed and maintained so that water does not pond at the crest or toe of critical slopes. To stop scouring on a face, water should not be discharged over a face except in a single controlled point. If possible, the water should be directed along the bench to the roadway, and along an open drain to a collection point, sump or settling pond.

## 3.6 GROUND SUPPORT AND REINFORCEMENT SYSTEMS

A number of factors influence whether ground support is required. The basic principle of ground support and reinforcement is to allow the operator to maintain the same overall slope angle while retaining the overall factor of safety. This is important when addressing zones of weakness to maintain a consistent design shape. Safety is paramount, but economic viability and the various requirements based on operating type also influences design decisions.

Ground support and reinforcement systems (artificial support) may include retaining walls, placement of rock or cable bolts. It also may include structures such as drilled or cast in-place piles, earth and rock anchors, reinforced earth including the use of geotextile and protection against erosion.

### 3.6.1 DESIGN CONSIDERATIONS

When providing artificial support you should match the design of the support system to the ground conditions. Design methods for artificial support should consider:

> the function of the support (eg to prevent rock fall, slope failure or rock slide)
> geological structure in and around the slope
> in situ rock mass strength and behaviour of the rock support or reinforcement system under load
> groundwater regime and chemistry, rock stress levels and the changes in rock stress during the life of the excavation
> the potential for seismic events (earthquake or blasting)
> retaining the overall factor of safety.

**Effect of timing of installation:** Generally, the earlier artificial support is installed the more effective it is. In areas requiring support, installation should be undertaken as soon as practicable to limit potential loosening and unravelling of the rock mass. Extended delays in the installation may jeopardise effectiveness of the artificial support. Ideally, identified wedges or blocks that are potentially unstable should be secured as excavation continues, with artificial support being installed progressively.

**Corrosion:** The influence of corrosion means no conventional forms of artificial support will last indefinitely – they all have a finite design life. The use of galvanised components is one way in which the life of the support will be prolonged.

**Quality control:** Each element or layer of artificial support should be combined so that the overall system is well-matched to the ground conditions for the design life of the excavation.

You should develop a quality control procedure to ensure the standard of installation of artificial support meets the design expectations for all ground conditions at the site.

### 3.6.2 ARTIFICIAL SUPPORT MEASURES

Artificial support measures can be categorised into four main groups (Read and Stacey 2009):

> rock bolting systems
> retaining type structures
> surface treatments
> buttressing.

#### ROCK BOLTING SYSTEMS

Rock bolting systems typically fall into three categories: rock bolts, dowels (shear pins) and cable bolts. Rock bolting systems can be improved by connecting individual components by welded mesh or strapping.

More information on rock bolting systems can be found in Appendix G: Rock Bolting Systems.

#### RETAINING TYPE STRUCTURES

Retaining walls are typically formed from precast concrete or in situ poured concrete, steel sheet piling or bored piles. Walls can be reinforced or un-reinforced and can be tied back with tendons into the rock.

Proper drainage behind the wall is critical to their performance. Drainage material will reduce or eliminate the hydraulic pressure and increase the stability of the fill material behind the wall.

More information on retaining type structures can be found in Appendix H: Retaining type structures.

#### SURFACE TREATMENTS

**Shotcrete** lining provides ground support and can lock key blocks into place. It also protects the rock against erosion by water and weathering. To protect water-sensitive ground, the shotcrete should be continuous and crack-free and reinforced with a wire mesh or fibres.

**Fibrecrete** (steel fibre reinforced shotcrete) was introduced in the 1970s and has gained worldwide acceptance as a replacement for traditional wire mesh reinforced plain shotcrete. Steel fibres are incorporated in the shotcrete to improve its crack resistance, ductility, energy absorption and impact resistance characteristics. Properly designed, fibrecrete can reduce or eliminate cracking, a common problem in plain shotcrete.

**Slope erosion protective measures** – slopes which are highly susceptible to erosion should be protected from rain and wind. A rock or cobble cover of 300 mm thickness is usually sufficient to protect against wind and rain. Alternatively grasses can be used.

**Rock netting** – linked steel wire and rings connected into sheets. Draped over a face, they limit rock movement and the energy in any movement. Useful in poor ground where fretting needs to be controlled.

**Hydro-seeding** – is a popular method of quickly establishing grasses on steep batters.

#### BUTTRESSING

A simple method of increasing slope stability is to increase the weight of material at the toe, creating a counterforce that resists failure. A berm or buttress of earth or rock fall can simply be dumped onto the toe of the slope.

Brocken rock or riprap is preferred to overburden because it has a greater frictional resistance to shear and is free draining, reducing problems with plugging groundwater flow.

Shear trenches or shear keys provide increased shearing resistance to failure and also serve as a subsurface drain. A shear trench is frequently a good supplement to flattened slopes and berms. Shear trenches should extend the full length of the slope.

PART B

# 04/

# PLANNING FOR TIPS, PONDS, VOIDS AND DAMS

## IN THIS SECTION:


4.1 Appraisal of tips, ponds and voids principal hazard

4.2 Tips, ponds or voids principal hazard management plan (PHMP)

4.3 Planning and design criteria for tips

4.4 Planning and design criteria for ponds or dams

4.5 Construction of a tip or pond

4.6 Rehabilitation of tips

## A well designed and constructed tip, pond or dam will have the lowest long-term and operational risk (eg structural failure).

This section describes:

- how to identify and manage hazards from tips, ponds, voids, and dams
- the role of geotechnical assessments
- criteria for planning and designing tips, ponds, and dams
- processes for constructing and maintaining safe tips, ponds, and dams.

The design of tips, ponds or dams should allow for:

- slope of the foundation
- geotechnical properties of the base and material
- earthquake risk
- surrounding area drainage, surface drainage and under-drainage
- size and lifespan
- adjacent infrastructure and land ownership
- final landscape and stability requirements
- equipment and operational methods to be used.

### 4.1 APPRAISAL OF TIPS, PONDS AND VOIDS PRINCIPAL HAZARD

> The SSE must carry out an appraisal of the mining operation to identify principal hazards at the mining operation[6].

To determine if tips, ponds or voids are a principal hazard, you should consider how a tip, pond or void might feasibly fail, and the likely consequences of any such failure. The probability of such a failure actually happening is not relevant in this context.

The consequences depend on:

- the likely scale of the failure (ie the size of the failure and the area affected by it)
- whether people are likely to be fatally injured.

Use a competent person for technical input and advice during the appraisal process, as required.

As a guide, complete an appraisal to determine whether a tips, ponds or voids principal hazard exists where:

- The tip is, or will be, in a wholly or mainly solid state and not in solution or suspension (ie not likely to flow if not contained) and
  - the area of the tip exceeds 10,000 $m^2$ or
  - the height of the tip exceeds 15 m or
  - the average gradient of the land covered by the tip exceeds 1 in 12.

Or

- The tip or pond contains, or will contain, any liquid or material wholly or mainly in solution or suspension (ie likely to flow if not contained) and
  - the contents of the tip or pond is more than 4 m above the level of any land which is within 50 m of its perimeter or
  - the contents of the pond exceeds 20,000 $m^3$.

Or

- Irrespective of the size of the tip, pond or void, other factors (eg the geology, location or proximity to an excavation) means there is a principal hazard.

Or

- Vehicles operate near the edge of a tip, pond or void.

[6] The Regulations, regulation 66 (1) (a)

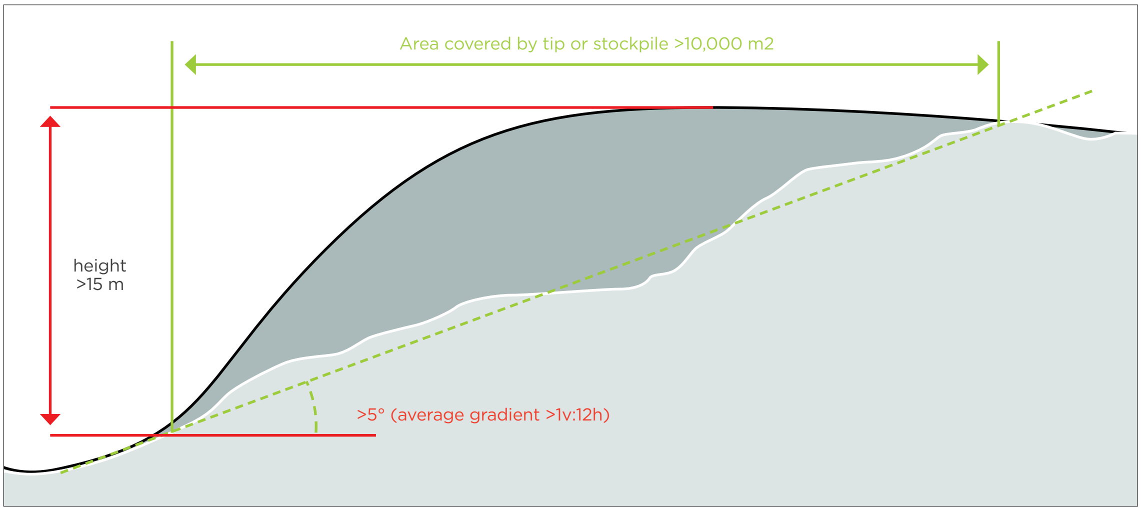



**Figure 12:** Guidance for tips (solid)

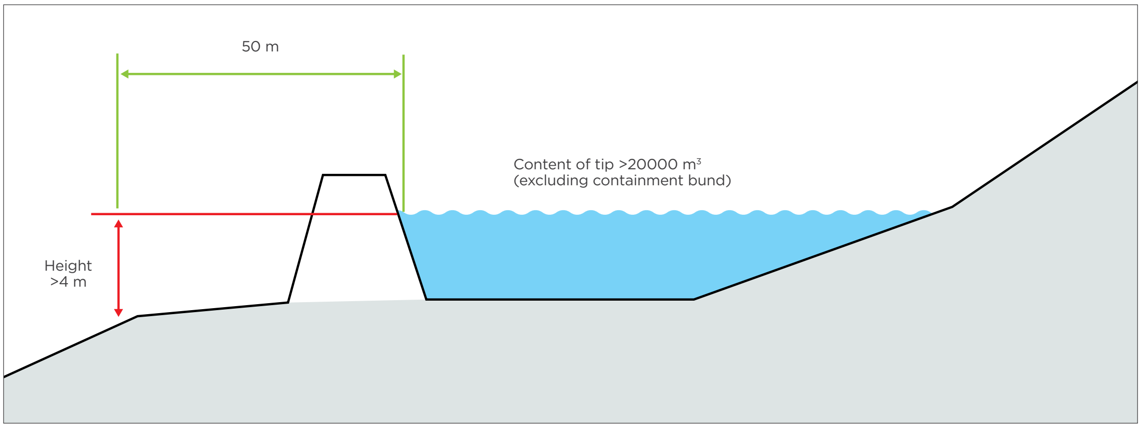



**Figure 13:** Guidance for tips (liquid) and ponds

A risk assessment must be completed for the tips, ponds, and voids principal hazard. A description of how the risk assessment will be conducted and the results of the risk assessment must be included in the tips, ponds, and voids PHMP[7].

In addition to the above, the SSE must ensure a risk reassessment of the stability of the tip, pond, or void is carried out by a competent person at least once every 2 years after the date the SSE has approved the PHMP, and, where construction of a tip, pond or void deviates from the geotechnical design, and, if a new tip, pond or void is created[8].

[7] The Regulations, regulations 68 (b) and (c)
[8] The Regulations, regulation 82

## 4.2 TIPS, PONDS AND VOIDS PRINCIPAL HAZARD MANAGEMENT PLAN (PHMP)

Where an appraisal has recognised a principal hazard, the SSE must ensure there is a principal hazard management plan (PHMP) for it[9].

Regardless of the result of the risk appraisal, a mining operation must have a PHMP if a tip is or will be:

> located on a slope
> greater than 15 metres high
> greater than 100,000 m$^3$ in volume[10].

The tips, ponds or voids PHMP must contain information detailed in regulations 68 and 81 of the Regulations. In summary, regulation 81 requires information on:

> procedures and processes for the safe design, construction and maintenance of tips, ponds or voids
> a geotechnical assessment
> road design and traffic movement
> the dumping rules
> records of material tipped
> an inspection and monitoring regime.

Where regular inspections are required by the PHMP, the PHMP must specify the nature and interval of inspections. It must also specify the appointment of a competent person to supervise the conduct of dumping operations, including a requirement this person supervises every inspection of a tip on the site[11].

The tips, ponds and voids PHMP should be developed in the context of the whole health and safety management system, not in isolation. This will ensure gaps and overlaps are identified and used in the implementing of suitable controls for tips, ponds, and voids.

For more detailed information on the content of the PHMP, and its relationship with other management and controls plans, processes and procedures see WorkSafe's *Guidance for a hazard management system for mines.*

### 4.2.1 GEOTECHNICAL ASSESSMENT

Where a tip, pond or void has been appraised as a principal hazard, the PHMP must include a geotechnical assessment. This must be proportionate with the type and scale of tipping operations and consider:

> the underlying geotechnical structure at the tip site
> the properties of the material being tipped
> the creation of any ponds or voids[12].

A geotechnical assessment will dictate any foundation and surface treatment required and may include any or all of:

> removal of unsuitable, weak material in the foundation
> benching of the foundation
> installation of under-drains and final slope toe drains
> installation of surface cut-off drains.

Using data collected from the geotechnical assessment, develop a geotechnical design which establishes appropriate foundations. A geotechnical recommendation for the maximum lift height, depths, volumes and maximum overall tip height should be provided as part of the geotechnical design.

### 4.2.2 RECORDS TO BE KEPT

Where a tip or pond has been appraised as a principal hazard, the PHMP must provide for record keeping of the materials being tipped[13]. Quarry and alluvial mines are recommended to keep records where the tip or pond has been appraised as a principal hazard.

[9] The Regulations, regulation 66 (1) (b)
[10] The Regulations, regulation 66 (c)
[11] The Regulations, regulation 83
[12] The Regulations, regulation 81 (b)
[13] The Regulations, regulation 81 (e)

## 4.3 PLANNING AND DESIGN CRITERIA FOR TIPS

You should proactively design and plan dumping activities – not rely solely on "reactionary design". You should be aware of the properties of the overburden, and the influence of the local environment on tip stability.

To make sure health and safety hazards are controlled, consider:

> the geological nature of the area (in particular the foundation of the tip)
> the quantity, type, and rehabilitation of overburden
> the type and size of the mobile plant to be used and access roads for vehicles and pedestrians
> preparation of the receiving area
> settling requirements, drainage and runoff controls
> stabilising methods, including inspections
> spontaneous combustion susceptibility
> controlling public access
> any other hazards which may affect safety (eg overhead power lines).

Tips should be designed to take into account the full range of foundation materials, tip materials and ground and surface water conditions.

Prepare all tip sites to safely receive the material. This includes removal of vegetation and topsoil, and keying into the substrata to ensure the stability of the material placed above.

Where tree felling is required, competent workers with appropriate tree felling qualifications must be used to undertake the work. You must notify WorkSafe in writing at least 24 hours before you intend to undertake tree-felling[14].

Subsoil drainage should be considered, to ensure there can be no liquefaction of the material placed there. Subsoil drainage can be as simple as placing large rocks to allow moisture to "wick" through. However, this could be a more sophisticated system using drain coil and piping to capture and transport moisture through the material, to a controlled discharge below the tip. Design water diversion and drainage structures according to acceptable engineering standards and perform to these for the full life of the tip. Where rehabilitation is required, undertake this as soon as possible to prevent scouring and water damage through erosion.

Design access roads and other vehicle operating areas to acceptable engineering standards for the number and type of vehicles requiring access. Design criteria should include road width, road gradient, edge protection, signage, speed limits, lighting, overhead hazards and passing rules. Refer to section 5 for further information on roads.

Adjacent stockpiles can have an effect on each other; for example, stability may be altered where they overlap. The adequacy of vehicle routes should also be considered when planning the position and size of stockpiles. In particular, the risk of collision can be minimised by ensuring a clear field of view for drivers (refer section 11.9.4).

As part of planning you should include appropriate edge protection (refer sections 5.3.9 and 8.2.3).

[14] *Health and Safety in Employment Regulations 1995*, regulation 26

## 4.4 PLANNING AND DESIGN CRITERIA FOR PONDS OR DAMS

The site for a pond (or tailings dam) must be selected to eliminate hazards or minimise the potential impact on people. This includes during operations, decommissioning and after abandonment, particularly in the event of the following:

> seepage
> dust generation
> exposure to chemicals or hazardous particulates
> erosion
> overtopping
> abrupt failure of retaining structure
> impediment of surface water flows
> pollution.

Physical factors that should be considered during site selection and design include:

> hydrology (potential for flooding and catchment area characteristics)
> topography (influence of watershed, streams, and creek systems)
> foundation material (water tightness, strength, and liquefaction potential)
> foundation conditions (physical, geochemical, and geotechnical properties)
> characteristics of construction (suitability, availability, and proximity)
> characteristics of tailings material (physical, geochemical and geotechnical properties)
> climate (rainfall patterns, evaporation rates and prevailing winds)
> geology (faults, fractures, shear zones and areas of instability)
> hydrogeology (potential impact on ground water resources)
> seismicity
> minimum freeboard
> seepage control methods
> characteristics of embankment or other retaining structures (stability, erosion resistance, resistance to dynamic or static liquefaction and integrated waste landform)
> operating strategy
> requirement for access
> characteristics and availability of cover and rehabilitation methods
> whether there are any populated areas downstream which may be adversely affected in the event of a failure.

Site abandonment should be considered during the design stage to ensure post-abandonment performance will meet stakeholder expectations and regulatory requirements. Abandonment and rehabilitation planning should ensure the pond disposal area is left such that it is able to:

> maintain an acceptable level of hazard controls (eg for dust control, access, and so on)
> remain structurally stable
> resist deterioration through erosion and decay
> prevent loss of containment.

## 4.5 CONSTRUCTION OF A TIP OR POND

You should develop and implement a construction plan to ensure the tip or pond construction meets design specifications and tolerances. This should include quality assurance procedures. The plan should also contain systems of work and procedures to ensure the proposed construction can be carried out safely.

Use a competent person to ensure construction of tips or ponds meet design specifications and tolerances, and that the following are documented:

> the conditions encountered during construction (including field and laboratory testing). This should be verified against those assumed in the design
> corrective measures taken where conditions did not meet the original design or specifications
> all changes required that deviated from the original design
> the testing and measurement regime to validate the design parameters
> survey data and drawings of the tip or pond construction.

The true locations of the following features should be shown in your design:

> borrow pits and embankments
> drains and seeping trenches
> topsoil stockpiles and capping material sources
> process water and return water ponds
> monitoring instrumentation
> decant towers
> buried pipework and cables.

The construction records and monitoring data form the basis of the design of subsequent stages. Where construction is staged, a separate construction report should be prepared for each stage.

Your tip or pond may also be considered a dam under the *Building Act 2004*. You can view the *Building Act 2004* at www.legislation.govt.nz.

#### 4.5.1 DRAINAGE OF A TIP

If sufficient water is present, either from heavy rainfall or other sources, some or all of a tip can become saturated. In this case the water in the saturated portion has a buoyant effect and reduces the strength of the material, making the tip more prone to sliding. As such, measures should be taken to ensure water drains away. Water should never be allowed to accumulate against or on any part of the tip, unless it is specifically designed as a dam or pond.

Where tips are constructed above an existing water course, the water course should be diverted or culverts of sufficient size provided to channel the water through the tip area.

The tip should have internal drainage to deal with expected rainfall. This is usually provided by under-tip drains or coarse, permeable layers positioned at appropriate levels. Internal drainage systems should be designed by a suitably competent engineer or hydrologist.

Drainage systems must be maintained.

#### 4.5.2 DAM SAFETY SCHEME

For storing water or another fluid under constant pressure you must comply with the requirements of a dam, as set out in the *Building Act 2004*. Structures at extractives sites that may fit the definition of a dam include settling ponds, tailing dams and reservoirs.

For more detailed information on dam notifications, dam classification, dam safety assurance programmes or dam compliance certificates see www.dbh.govt.nz.

#### 4.5.3 SMALL DAMS

Dams are to be designed, built and maintained to an appropriate standard. Substandard dams can fail, causing injury to workers, as well as, damage to equipment and financial loss.

The following information was supplied by the Ministry of Business, Innovation and Employment. The information does not prescribe how small dams should be constructed or maintained. It is a guide on ensuring a dam complies with statutory requirements, including those in the *Building Act 2004*.

For further general information on inspecting small dams, constructing small dams or the *Building Code* see the following documents available at www.dbh.govt.nz/small-dams-guidance:

> *The New Zealand Society of Large Dams (NZSOLD) – Guidelines on inspecting small dams.*

> *The Auckland Regional Council – Dam Safety Guidelines.*

> *The Building Regulations 1992 (Building Code)*.

As provided by guidance issued by MBIE, a small dam can be considered any dam that:

(a) has a height of less than 4 metres; or

(b) holds less than 20,000 cubic metres volume.

However, the Act states that all building work carried out must comply with the Building Regulations 1992 (also known as the Building Code). Building work includes the construction and alteration of small dams even though they are exempt from requiring a building consent for this work.

The *Building Code* sets out performance standards that building work must meet, and covers aspects such as structural stability and durability. The *Building Code* does not prescribe how building work should be done (it has no detailed requirements for design and construction), but states how completed building work, and its components, must perform. This is important when considering the construction of a small dam, as each dam is unique to its location and environment.

Design, construct and maintain all dams in a way that:

> safeguards people and property from structural failure

> complies with the *Building Code* throughout its life

> has a low failure probability.

CONSTRUCTION OF A SMALL DAM

The construction of a small dam, although not requiring building consent, requires careful consideration of design and construction methodology. In the first instance, you should employ a technical expert to provide advice on designing and constructing a small dam to make sure it is fit for purpose and it complies with the *Building Code*.

A small dam is expected to have the following features:

**Foundations and structural support**

The areas of ground on which the dam is located (including the areas of adjacent ground) form part of the total water barrier. If the foundations do not adequately support the basic small dam structure, or are weak or prone to high seepage flows, they can cause the dam to become useless or to fail. The foundation of a small dam is often the natural materials on which it stands. A clean, stable foundation of adequate strength and low permeability is vital for a small dam's durability and performance. An adequate seal at the dam foundation and abutments must be formed to reduce leakage from the reservoir. Otherwise, it may not fill or excessive seepage may cause dam failure.

**Spillway and high stream flow prevention**

All dams require at least one working spillway. A flood spillway prevents high stream flows caused by heavy or prolonged downpours from overtopping the dam crest. This causes erosion of the dam materials, and may lead to a breach of the dam. The flood spillway is normally formed around the end of the small dam and extends downstream, clear of the dam toe. The flood spillway must be of a size adequate for flood flows expected for the rainfall and catchment size or topography. A smaller service spillway for a small dam may also exist and will normally be a culvert or pipe which takes normal flows.

**Storage capacity**

Assess the volume of storage to ensure it is large enough for the intended purpose. Sufficient freeboard must be provided to prevent overtopping of the dam.

**Embankment and slope angles**

The embankment must have a crest of sufficient width, and may require protection if vehicles or heavy stock will have access. The upstream and downstream slope angles need to be chosen carefully, to ensure the embankment slopes are stable. To ensure a high standard of compaction, the fill material needs to be carefully selected, sufficiently impervious, and placed at the correct moisture level and thickness of each layer. Riprap may be required on the upstream face to protect the dam against wave lap erosion.

**Pipes and conduits**

Pipes are often placed through the bottom of the dam for drawing of water. However, it is important to note these can also be weak points for seepage, causing erosion of the dam fill. Technical advice is recommended for correct design details where pipes pass through a dam.

## 4.6 REHABILITATION OF TIPS

When the site is temporarily (suspended) or permanently closed (abandoned), it should be left in a safe condition.

Typically rehabilitation is carried out progressively, meaning parts of the site can be abandoned, while other parts are still operational; for example, rehabilitation of overburden tips that have reached capacity.

The objectives of abandonment of all or part of a site are:

> to ensure the public is safe by preventing inadvertent access to site infrastructure

> to provide for the stable, long-term storage of overburden and tailings

> to make sure the site is self-sustaining and prevent or minimise environmental impacts

> to rehabilitate disturbed areas for a land use (eg return of disturbed areas to a natural state or other acceptable land use).

Rehabilitation should address management of water runoff, air quality, stability of material, erosion control, and treatment and containment of any possible hazardous substances.

Stability of material and control of water runoff are the most important as they will be the first indicators of any problems in the rehabilitated area. Stability should be monitored by study of the toe area of any overburden tip. Ensure it is well compacted and not bulging or moving out from its original placement. Another indicator of movement would be cracks appearing around the crest or top of the rehabilitated tip.

Rehabilitation is a requirement for all new resource consents and most current resource consents.

Rehabilitation should be considered and incorporated into all aspects of site planning, construction and operation. This allows key aspects of the abandonment to be planned for throughout the site's life cycle. Plans should identify measures to be undertaken during the operations phase that are aimed at progressive rehabilitation of disturbed or developed areas of the site.

Review and revise rehabilitation plans as necessary throughout the site's life cycle. The plans may become more detailed, incorporating more activities related to the site and consideration of more site conditions and monitoring results.

PART B

# 05/

# PLANNING FOR ROADS AND VEHICLE OPERATING AREAS

## IN THIS SECTION:

5.1 Appraisal of roads and other vehicle operating areas

5.2 Roads and other vehicle operating areas principal hazard management plan

5.3 Design and layout of roads

**Roads and other vehicle operating areas can introduce significant hazards at an extractives site. However, a well-designed and maintained site will make workplace vehicle accidents less likely.**

This section describes how to:

> identify and manage hazards from roads and other vehicle operating areas
> plan and design safe vehicle routes, road structures, gradients, corners, drainage, surfacing, visibility, and areas for working, turning, and stopping
> manage traffic and provide clear information and guidance for drivers.

The overall message is **safety by design**.

Considering what vehicle activities will be conducted on a road or other vehicle operating areas will help determine the kind of hazards that may be present. The unwanted events associated with roads and other vehicle operating areas include:

> vehicles rolling over or going over edges
> ground failure on to or below vehicles
> collisions between vehicles and unwanted interaction between vehicles and people
> uncontrolled movement of vehicles
> vehicles contacting overhead power lines or other structures.

Assessing the risks will help you take the correct action to eliminate, isolate or minimise hazards.

## 5.1 APPRAISAL OF ROADS AND OTHER VEHICLE OPERATING AREAS

The SSE must carry out an appraisal of the mining operation to identify principal hazards at the mining operation[20].

To determine if roads and other vehicle operating areas are a principal hazard, consider the following factors. The probability of such a failure actually happening is not relevant in this context.

> How a road or other vehicle operating area might feasibly fail and the likely consequences of a failure (eg collapse, slips).
> The type of vehicles using the road or other vehicle operating area.
> The activities that are undertaken and the consequence of any interactions between vehicles and pedestrians, structures or other vehicles. For example vehicles carrying passengers, light and heavy vehicle interactions, travelling under overhead power lines, loading over a cab where a driver may be present and so on.
> How a vehicle may lose control and the likely consequences (eg driver falling asleep, mechanical failure, tip over).
> The hazards on the road or other vehicle operating area (eg sharp corners, steep gradients, large drop-offs and so on).
> Any other hazard involving vehicles.

Use competent people for technical input and advice during the appraisal process as required.

A risk assessment must be completed for the roads and other vehicle operating areas principal hazard. A description of how the risk assessment will be conducted and the results must be included in the Roads and Other Vehicle Operating Areas PHMP[21].

[20] The Regulations, regulation 66 (1) (a)
[21] The Regulations, regulations 68 (b) and (c)

Regularly renew whether intersections and roads are necessary.

## 5.2 ROADS AND OTHER VEHICLE OPERATING AREAS PRINCIPAL HAZARD MANAGEMENT PLAN

Where an appraisal has recognised a principal hazard, the SSE must ensure there is a PHMP[22].

The roads and other vehicle operating areas PHMP must contain information detailed in regulations 68 and 80 of the Regulations. Regulation 80 requires the PHMP to provide for the following areas including:

General road design:

> controls for the safe design, layout, operation, construction and maintenance of roads and other vehicle operating areas
> road maximum grade, minimum widths and radius for curves, camber, surface material specifications and drainage needs.

Measures to control risks associated with:

> any banks, steep drops or any other hazard adjacent to the road or other vehicle operating area
> interactions between vehicles, considering speed, volume and other relevant matters
> interaction between site vehicles and public vehicles
> interactions between vehicles and pedestrians
> interaction between vehicles and fixed structures (eg gas pipes and processing machinery) including overhead and underground power lines
> the use of remote control vehicles
> adverse climatic conditions (eg rain, ice, fog).

In relation to dump trucks:

> the design, construction, and maintenance of safety benches, windrows and collision bunds
> measures to manage the risks of trucks overturning
> safe tip areas and routes
> recommended methods of safe working.

Procedures for the operation and movement of loads:

> shifting equipment and discharging loads
> the maximum loads that can be carried or towed.

Worker safety:

> how workers will safely access and exit their place of work
> how workers will safely work or travel on or near roads or other vehicle operating areas
> areas to be considered prohibited zones.

Vehicle safety and maintenance:

> park-up, refuelling and recharging safety requirements
> the safe storage of fuel
> the periodic inspection and testing of the braking system
> the safe operation and requirements of vehicles carrying passengers or transporting equipment including separation of loads, the use of seat belts or other restraint devices and the provision of seating
> how defects identified when inspecting vehicles will be addressed.

The roads and other vehicle operating areas PHMP should be developed in the context of the whole health and safety management system, and not in isolation. This will ensure gaps and overlaps are identified and used in the implementing of suitable controls roads and other vehicle operating areas.

For roads and other vehicle operating areas recognised as a principal hazard, it is likely a mechanical engineering PCP will also be required.

[22] The Regulations, regulation 66 (1) (b)

For more detailed information on the content of the PHMP, and its relationship with other management and controls plans, processes and procedures see WorkSafe's *Guidance for a Hazard Management System for Mines.*

## 5.3 DESIGN AND LAYOUT OF ROADS

Every site is different and likely to present different hazards and risks. However, a well-designed and maintained site with suitable separation of vehicles and people will make vehicle accidents less likely.

Safe workplaces are achieved by separating pedestrians and vehicles, light and heavy vehicles, and providing hazard-free vehicle routes.

### 5.3.1 TERRAIN AND GEOTECHNICAL CONSIDERATIONS

Take into account the terrain and geotechnical issues when designing and establishing roads. They will impact on the type of operation that will be carried out, the mobile equipment to be used, and where infrastructure can be located.

### 5.3.2 OPERATIONAL PARAMETERS

Consider how operating parameters will impact on the design, layout, and materials used to construct the road and maintenance requirements prior to constructing and establishing roads. This includes:

- the nature, type and, load of vehicles to use the road
- expected volume of traffic
- operating hours
- vehicle operating speeds
- gradients (including superelevation)
- materials available for road construction and maintenance.

### 5.3.3 VEHICLE ROUTES

Where practicable you must eliminate the hazard of pedestrians and vehicles interacting. The most effective way of achieving this is to provide separate pedestrian and vehicle routes, and where practicable, separating light and heavy vehicles.

Design roads that are:

- adequate for the number, type and size of the largest vehicles that may use them
- suitable for the varying driver positions which includes height and cab position (eg right, left or centre drivers position).

Roads should:

- have firm surfaces, adequate drainage and safe profiles to allow safe vehicle movements
- be clearly signed
- where appropriate, have edge protection and road markings (eg sealed roads) or delineators showing the right of way
- have speed limits and speed control measures specific to site conditions and the types of vehicles using the route
- have adequate rock fall protection measures (eg a catch ditch, catch bench or suitable barrier)
- be clearly delineated in the hours of darkness by using reflective marker pegs or similar devices or have suitable access restrictions to hazards (eg ponds or other water filled hazards or steep drop-offs)
- allow for break back of the bench crest during the life of the road. The amount of break back will depend on geotechnical characteristics of the bench
- minimise the need for reversing with one-way systems and turning points
- accommodate the turning circles of vehicles.

Also consider:

> access to the site including weight restrictions on bridges, narrow roads and so on
> where distribution points will be (eg processing areas, weighbridge location, load covering areas, loading areas, points of sale to the public)
> impacts of land adjacent to the road.

Where practicable, road design should avoid:

> unstable areas
> hazards such as excavations, ponds, structures, fuel or chemical storage areas, underground workings or voids and overhead power lines
> steep gradients and tight bends
> one-lane two-way routes.

You may need to engage a specialist traffic engineer for complex traffic flows, especially at sites with large processing operations.

### 5.3.4 ROAD WIDTHS

The width of a road should be based on the size of the largest vehicle in use. The larger the vehicle, the more clearance is required.

Each lane of travel should be at least 1.5 times the width of the widest vehicle that would normally use the road. For a two-lane road, the width should be at least 3 times the width of the largest vehicle. Provide extra room for drains, windrows or centre windrows (refer Figure 14).

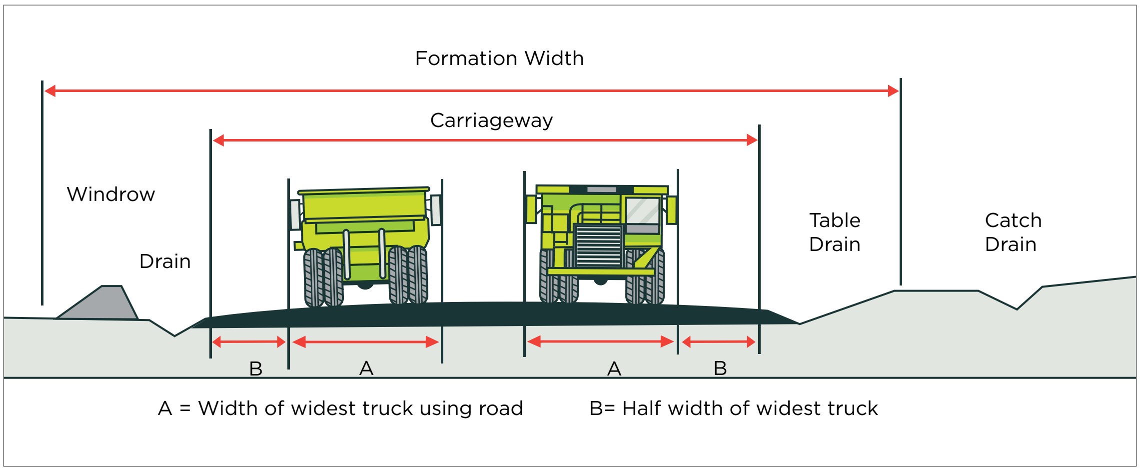



**Figure 14:** Example road layout with clearance between lanes

Where it is not practicable to have two lane roads, adequate passing bays and turning points should be provided. One-lane roads and turning points are not recommended on haul roads.

It may be appropriate to use turning bays to allow vehicles to turn and drive forwards for most of the time. Turning bays would ideally be a roundabout or a 'banjo' type. Although, 'hammerhead' and 'stub' arrangements may be acceptable.

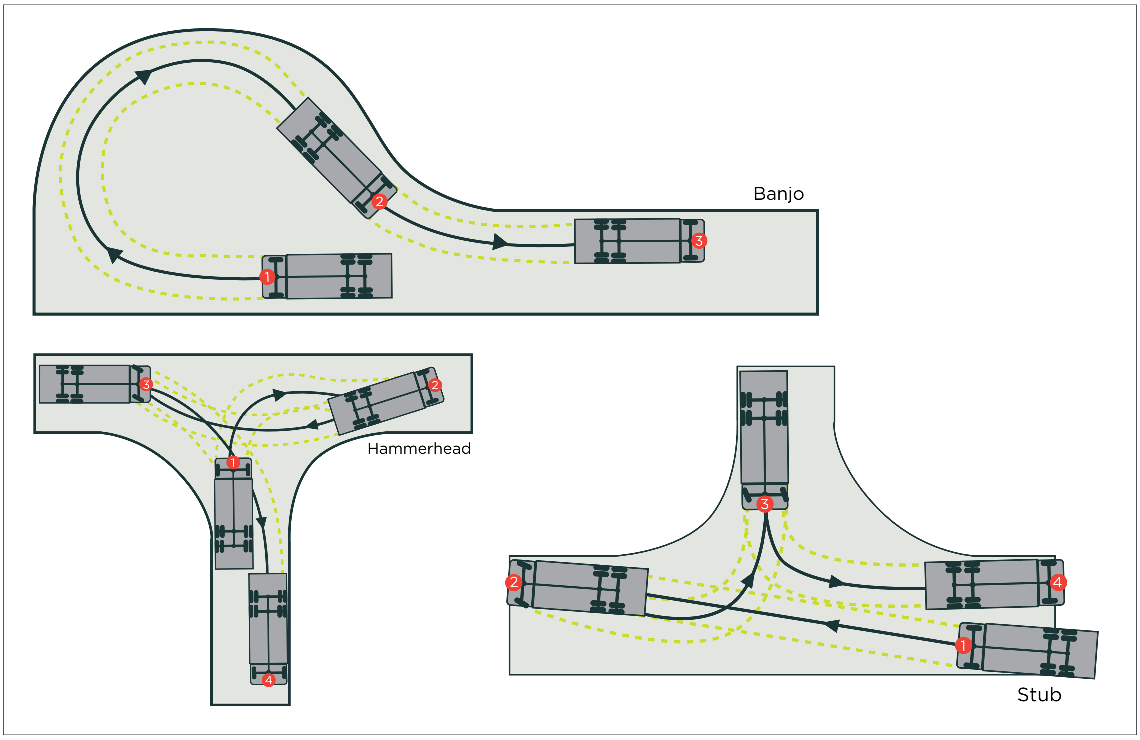



**Figure 15:** Turning arrangements

Where reasonably practicable provide segregation of light vehicle on roads also used by off road dump trucks. This is to eliminate interactions between light and heavy vehicles (refer Figure 16).

The hierarchy of controls for controlling light and heavy vehicle interactions is:

1. Separation (different haul road).
2. Segregation (bund separation on same haul road).
3. Administrative controls.

Consider the interactions of light and heavy vehicles when entering and leaving haul roads.

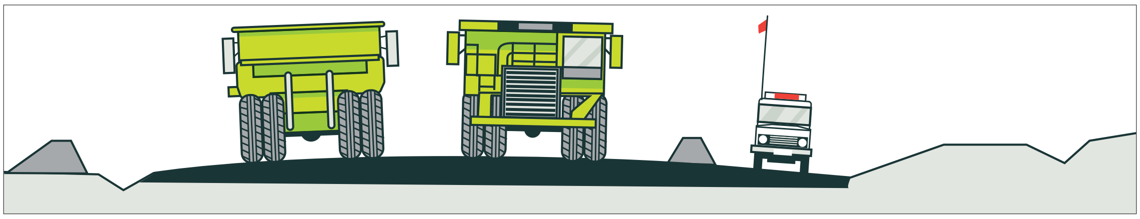


**Figure 16:** Segregation of light vehicles

Bends on haul roads should be designed wider than the straight stretch to allow for overhang of vehicles using it. Switchbacks or other areas on haul roads requiring sharp curves should be designed to take into account the minimum turning radius of the haul trucks.

### 5.3.5 ROAD GRADIENT

Five important aspects of the steepness or grade of a roadway are:

> the grade needs to be compatible with the braking capabilities of the vehicles (with a factor of safety)

> the grade needs to be compatible with the performance capabilities of the vehicles

> the grade will affect a vehicle's stopping distance

> the grade selected will have to take into account a vehicle's ability to operate safely in wet conditions

> superelevation affects the speed around bends.

#### DETERMINING THE GRADE OF A ROAD

The steepness of a road is normally expressed as a ratio. The ratio is determined by measuring the distance travelled along the road in relation to the vertical height change (see Figure 17). For example, a road with a 1-metre vertical change over a travelling distance of 10 metres is a 1:10 ratio.

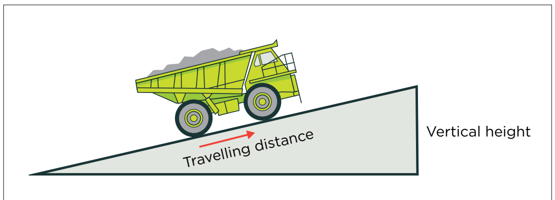



**Figure 17:** Road gradient

Information in vehicle manuals about braking and performance abilities on slopes may be provided as a grade percentage (see Appendix A for conversion chart).

The steepness of a road should be measured using surveying equipment. The grade should be determined over a portion of the road where the grade is constant. Where the steepness varies, the grades should be determined for different segments.

#### GRADE AND VEHICLE COMPATIBILITY

The grade of a road must be compatible with road conditions, the type of road surface and the vehicle capability. Vehicle brakes must be able to stop in the worst case scenario without losing control of the vehicle. Particular attention should be paid when loads are moved downhill.

Different vehicles, with different performance characteristics, will use the roads. Design the roads to allow all vehicles to operate within their safety parameters. Road grades should never be designed to the maximum climbing or descending capacity of the vehicles that use them. Generally, a gradient of 1:8 or less should be applied when planning haul road layouts.

It is important vehicles are not overloaded as brake or retarder performances depend on the grade and on the vehicle's total weight (refer 11.4.3).

#### GRADE SITUATIONS TO AVOID

Avoid road alignments that result in a sharp bend near the top of a grade. These are hard to see at night, when headlights tend to shine up into the darkness. If this cannot be avoided, the bend should be defined, for example, using extended reflective markers.

Also avoid sharp bends near the bottom of a grade. Here, vehicles tend to pick up momentum, making it more difficult to maintain control around the bend. If you cannot avoid a sharp bend, a safe speed for descending the grade should be posted as well as adequate restraining measures, such as large windrows or runaway provisions should be used (refer 5.3.9 and 5.3.10).

#### SUPERELEVATION

Superelevation is a technique used to assist vehicles in manoeuvring safely around corners. Superelevation is the banking of the road pavement at bends. It allows the vehicle taking the corner to counteract forces towards the outside of the bend, by directing the vehicles weight towards the centre or radius of the bend. The amount of superelevation on a bend is directly related to the radius of the corner and the desired vehicle speed through the corner.

The following table is a guide for providing the superelevation necessary to reduce lateral forces. The maximum superelevation should be regarded as 1:20.

| TURN RADIUS (M) | SPEED (KM/HR) | | | |
|---|---|---|---|---|
| | 16 | 24 | 32 | 40 |
| 45 | 1:25 | | | |
| 60 | 1:37.5 | | | |
| 90 | 1:50 | 1:20 | | |
| 150 | 1:100 | 1:37.5 | 1:20 | |
| 215 | 1:100 | 1:50 | 1:25 | |
| 300 | 1:100 | 1:50 | 1:37.5 | 1:25 |

**Table 4:** Recommended super-elevation

Superelevation is a particularly important design consideration for switchbacks on haul roads, as they typically have a small turn radius. On switchbacks, which have the centre of the bend located on the up-side of the road, a well-chosen superelevation rate prevents material being spilled from laden trucks and improves vehicle control.

As with changes in grade, transition into and out of superelevated bends needs to be smooth, so vehicles can be eased into corners. Superelevation transition lengths depend on the cross fall change and the design speeds. The larger the change in road alignment, the longer the transition needs to be. Transition lengths should be applied so one-third is on the bend and two-thirds are on the tangent (refer Figure 18). Table 5 outlines the recommended lengths.

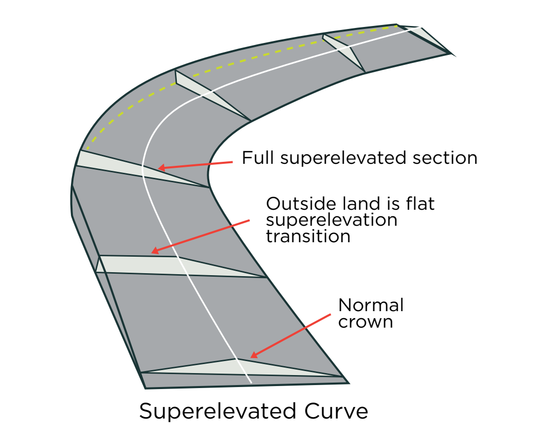



**Figure 18:** Superelevated bends

| VEHICLE SPEED (KM/HR) | 16 | 24 | 32 | 40 | 48 | 56 |
|---|---|---|---|---|---|---|
| Cross slope change per 100 m pavement | 0.08 m | 0.08 m | 0.08 m | 0.07 m | 0.06 m | 0.05 m |

**Table 5:** Recommended transition lengths

To illustrate the use of this table, assume a vehicle is travelling at 32 km/hr on normal pavement with a cross-fall of 2%. The vehicle is approaching a switchback with superelevation of 4% the opposite way. The total cross slope change here is 6% (2% plus 4%). For a vehicle travelling at 32 km/hr the recommended change is 0.08 m per 100 m. Therefore the total transition length is 75 metres ((6%/0.08 m) x 100 = 75 m).

### 5.3.6 SIGHT DISTANCE

"Sight distance" is simply how far along the road a driver can see ahead of their vehicle (see Figure 19). Roads should be designed to give drivers a sufficient distance of clear vision ahead so they can avoid unexpected obstacles. A basic rule of safe driving is that, at all times, a driver must be able to stop the vehicle within their sight distance. If a driver sees a problem, such as a boulder on the road or a stalled vehicle, they must be able to stop in time to avoid it.

Design roads with viewing distances and alignments so that a vehicle rounding a bend, cresting a hill, descending a grade, or approaching a junction can stop in time to avoid an object in the road or a vehicle pulling onto the road (refer Figure 20). Consideration should be given to the height of a driver in different vehicles.

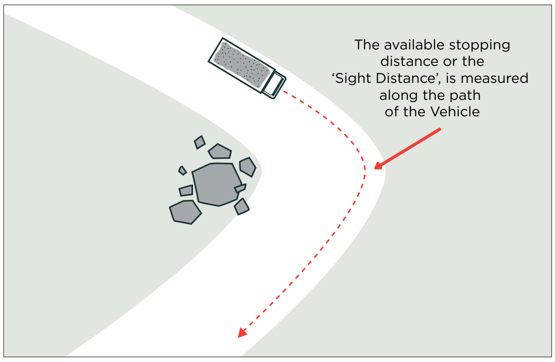



**Figure 19:** Sight distance

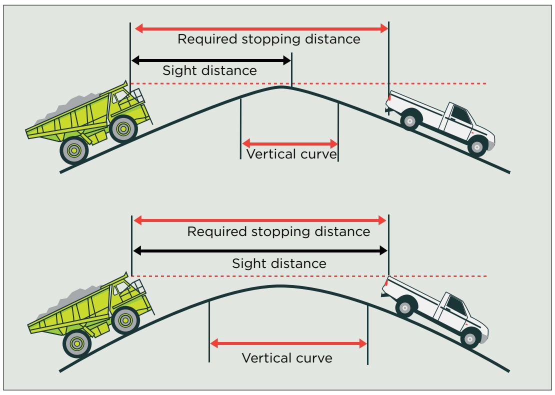



**Figure 20:** Road alignment

#### SIGHT DISTANCE IN BAD WEATHER OR AFTER DARK

The sight distance can be reduced during inclement weather, such as rain, snow or fog. Under these conditions, drivers must slow down to the point where they can stop within the available sight distance. Effective headlights and spotlights improve the ability to see and be seen.

When driving after dark, sight distance can be defined by the distance illuminated by the vehicle's headlights. Drivers should reduce their speed so they can bring the vehicle to a stop within the illuminated distance. This distance will vary with the type of headlight. To be most effective, you should keep headlights properly aimed and clean. Speeds should be reduced at night because drivers typically have reduced depth perception, peripheral vision and reaction time.

There is often little contrast in brightness between the background and other objects at an extractive site – especially in snow. Roadside reflectors should be installed to help define the roadway and intersections. Vehicles used at night should have lights that can be seen from the side of the vehicle, as well as the front and rear.

SIGHT DISTANCE AT INTERSECTIONS

Sight distance is important at intersections, where a driver must be able to see oncoming vehicles far enough away to safely turn on to or cross the road. Ideally, drivers should be able to pull on to the road, or cross the road, without requiring approaching vehicles to slow down. The main factors in the safe sight distance at intersections are the acceleration ability of the vehicles pulling on to the road and the speed of the oncoming traffic.

Because of the limited acceleration ability of trucks, especially when laden, ample sight distance should be provided. The higher the speed on the road, the longer the sight distance should be.

Avoid locating intersections near hill crests or sharp curves. In these situations, the sight distance will be limited. Intersections should be kept as flat as possible and sight distance should be considered in all directions.

In laying out intersections, the effect of the large blind spot to the right or left side of haulage trucks (depending on the position of the driver's seat), should be considered. Intersections where trucks need to stop or give way to other vehicles should be angled to optimise the driver's ability to see vehicles coming from both the right and left sides (refer Figures 21 and 22). For roads used by haulage trucks, avoid roads that intersect at an angle of less than 90 degrees on the opposite side of the driver. Alternatively compensating measures should be taken (eg convex mirrors, reduced speed zones, communication systems or on-board cameras).

When using 'Give Way' controls at an intersection you should have visibility clearance of 1.2 times the priority road speed limit, nine metres back from the intersection. Where you cannot achieve the visibility clearance a 'Stop' control should be used that requires vehicles to come to a complete stop (refer examples shown in Figures 23 and 24).

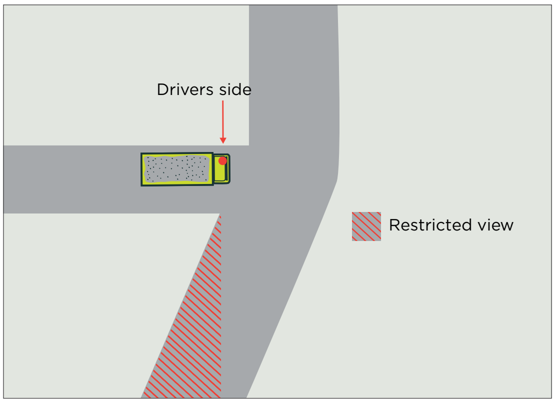



**Figure 21:** Intersection with restricted view

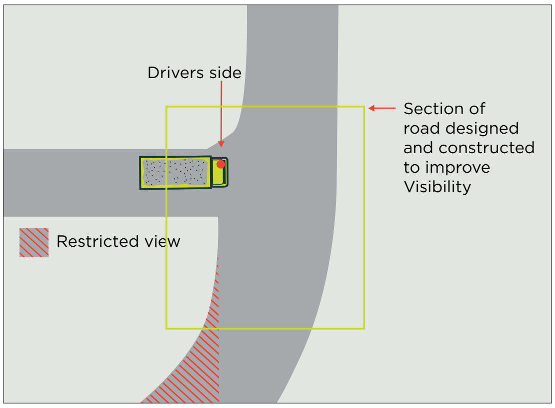
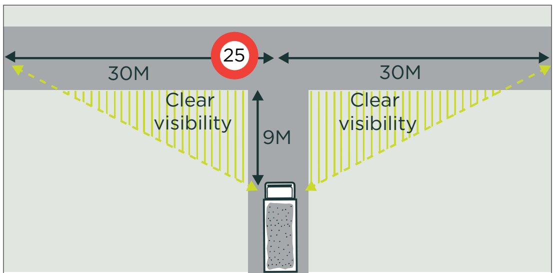



**Figure 22:** Intersection with improved visibility




Clear visibility 1.2 times (meters) priority road speed limit 9m from intersection
e.g. 25km/hr speed limit x 1.2 = 30 metres.
Therefore you should have 30m visibility 9m back from the intersection if using a "Give Way" control.

**Figure 23:** Give way control selection

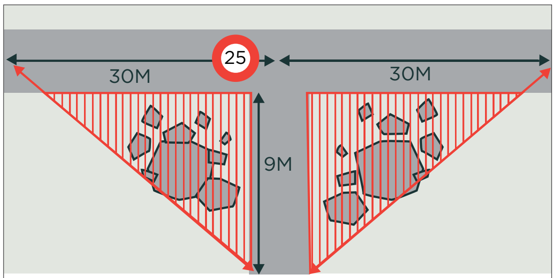



**Figure 24:** Stop control selection

### 5.3.7 DRAINAGE

Having good drainage systems will:

> prolong the life of the road
> reduce maintenance costs on roads and vehicles
> minimise downtime
> minimise health effects on drivers
> improve tyre life.

Drainage is normally provided using:

**Cross fall (or cross slope):** Surface drainage is designed to cause the water to leave the road as shallow, non-erosive sheet flow in a way suited to the road material, slope and terrain. To promote drainage either; the road surface should be sloped from one side to the other, or the road should be crowned, or raised, in the centre.

Typical cross falls for unpaved roads in New Zealand are 3.5 to 4% and 2 to 4% for paved roads. On haul roads a cross fall between 2% and 4% is preferred. Steeper crowns can increase tyre wear and metal fatigue in trucks. Cross falls should not be carried around a bend; instead there should be a transition zone between the normal cross fall road and the start of the superelevation of the bend. For more information about superelevation see section 5.3.5.4.

**Free-draining road materials** allow water on the road surface to drain down and out.

**Roadside ditches** collect drainage from the road surface and intercept runoff from adjacent hillsides, keeping it off the road surface.

**Culverts** carry runoff under the road surface to a drainage course. They vary in size from 300 mm concrete or corrugated metal pipes to large shapes 3 m or more in diameter. The inlets and outlets for the larger sections usually have concrete headwalls and wing walls to reduce erosion problems. The smaller pipes usually have bevelled end sections for the same reason.

When using culverts they should be buried deep enough to prevent them being crushed by vehicles passing over them. Manufacturers can provide information about suitable depth.

More information on culverts can be found in Appendix I: Culverts.

### 5.3.8 ROAD PAVEMENT

Surface and drain all roads adequately to make sure vehicles can be driven safely.

The materials that make up the road pavement and road base need to serve two functions:

> provide adequate traction
> provide support for the vehicles without excessive sinking in or rutting.

#### TRACTION

A road pavement of gravel or crushed stone is preferred for roads. While some other materials provide better traction when dry, a gravel road pavement offers good traction values in both wet and dry conditions. You may have to import gravel or crushed stone when not available on site. Alternatively, if all weather pavements are not practicable and roads become un-trafficable due to weather or under-foot conditions, have procedures in place that outline when operations should stop and when they can re-start. Base any such procedures on technically sound risk assessments.

More information on traction can be found in Appendix J: Traction.

SUPPORT

Rutting of a soft pavement can create a hazard by affecting a driver's ability to control the vehicle and by subjecting the driver to rough or jarring conditions. Rutting occurs when tyres sink into the pavement because the road material doesn't offer adequate support. Fine-grained soils, even when well-compacted, may not support the tyre loads imposed by large haul trucks, especially during wet conditions.

To prevent or minimise rutting of the road, a road base material with sufficient strength to support the tyre loadings should be provided. A layer of gravel or crushed stone, for example, has higher bearing strength and will distribute the tyre loadings over a larger area. The use of a layer of geotextile can assist in providing a road base that will better support the tyre loadings. A great deal of maintenance work will be necessary to keep the road in good condition where road base material has inadequate support strength.

### 5.3.9 ROADSIDE EDGE PROTECTION

The failure to provide adequate edge protection is the cause of many vehicle accidents. Provide adequate windrows or guardrails where there is a change of level, drop, pond, or other hazards which would put the driver, or others, at risk if the vehicle left the road.

Risk assessments will determine the type of edge protection or runaway provisions require.

PURPOSE OF WINDROWS

Roadside windrows are a common safety feature along elevated roadways. However, the capability of windrows may be misunderstood, and it's dangerous if they give drivers a false sense of security.

Windrows mainly:

- give the driver a visual indication of the location of the roadway edge
- provide a sense of contact to the driver if they accidentally contact the windrow
- provide restraint to the vehicle and give the operator the opportunity to regain control and keep the vehicle from leaving the road
- keep a vehicle back from the edge by a distance equal to at least the width of the windrow.

EARTHEN WINDROWS

Windrows used on roads where heavy vehicles operate need to be of sufficient height and width, constructed with suitable material and be steeper on the road side to serve the four functions indicated above.

Windrow suitability is normally judged based on its height, although the effectiveness of a windrow also depends on its width (or thickness) and its firmness.

Earthen windrows should be a minimum of half the wheel height of the largest vehicle that uses the roadway. Windrows less than this or with curved slopes, make an ideal ramp for vehicles to run over and are totally ineffective. Support installation and construction of windrows by robust design calculations determined by a competent person.

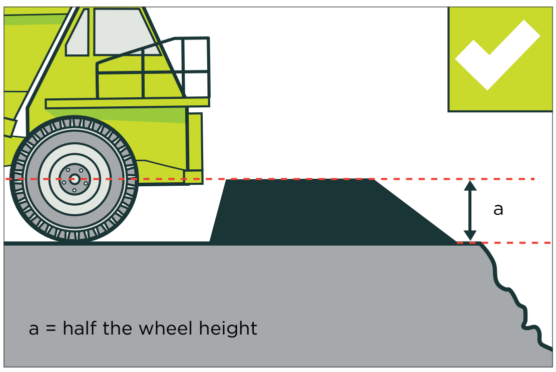



**Figure 25:** Suitable windrow – firm material big enough to absorb the vehicle's momentum with a steepened inside slope

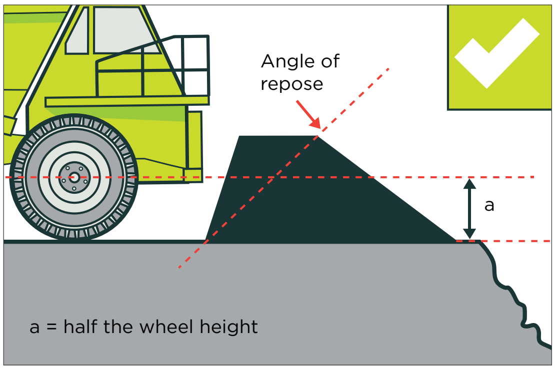



**Figure 26:** Suitable windrow – the width of the windrow is as wide as the normal angle of repose

For more information on windrows, see Appendix K: Windrows.

Windrows can deteriorate due to weathering, and should be regularly inspected and maintained to ensure their continued effectiveness. Mine operators must ensure a competent person inspects windrows at least weekly[23].

### BOULDER WINDROWS

Sometimes a continuous row of boulders is used to form a windrow. When a vehicle contacts a boulder windrow, the restraint comes from the frictional forces involved in sliding the boulder ahead of the vehicle. Boulders cannot be placed right at the edge of the drop off because there has to be a distance available for the vehicle to push the boulders. This distance will depend on the size of the boulders and the size and speed of the vehicle.

For that reason blocks of stone or tyres placed individually along the edge of a road which can be easily pushed out of the way by a vehicle, or increase the risk of injury to the driver, are not suitable for windrows (refer Figure 28). Blocks of stone or tyres may be used provided you heap materials (like scalping's) between the blocks or tyres so they can safely absorb the impact and not be easily pushed (refer Figure 27).

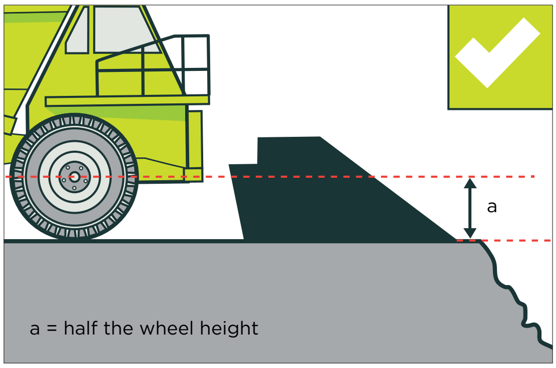



**Figure 27:** Suitable edge protection – a rock with material in between which can safely absorb the impact

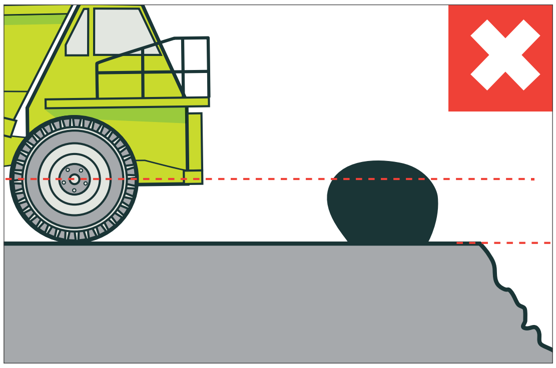


**Figure 28:** Unsuitable edge protection – blocks of stone can be pushed out of the way

### GUARDRAILS

You should engage a qualified engineer with suitable experience to determine adequate design and construction of guardrails, where used.

If guardrails are used instead of windrows, make sure they are capable of:

> providing a visual indicator of the location of the edge of the road
> giving a sensation of contact to the driver if the guardrail is accidentally contacted
> restraining or impeding the vehicle's passage over the edge.

Considering the large size and mass of haulage trucks, guardrails generally need

[23] The Regulations, regulation 222 (1) (a) (ii)

to be higher and stronger than the guardrails typically used on public roads.

Embed guardrail posts deep enough to provide adequate resistance and make the posts and horizontal guide members strong enough to restrain or impede the passage of the vehicle.

Installation and use should not exceed the manufacturers recommended limits in respect to vehicle type, size and weight.

### 5.3.10 RUNAWAY PROVISIONS

Safety features should be incorporated into road design to guard against the consequences of runaway vehicles. As previously discussed, typical edge-of-road windrows should not be relied on, by themselves, to stop a large haul truck. However, other methods such as the use of escape lanes can bring a runaway vehicle to a safe stop and prevent an accident.

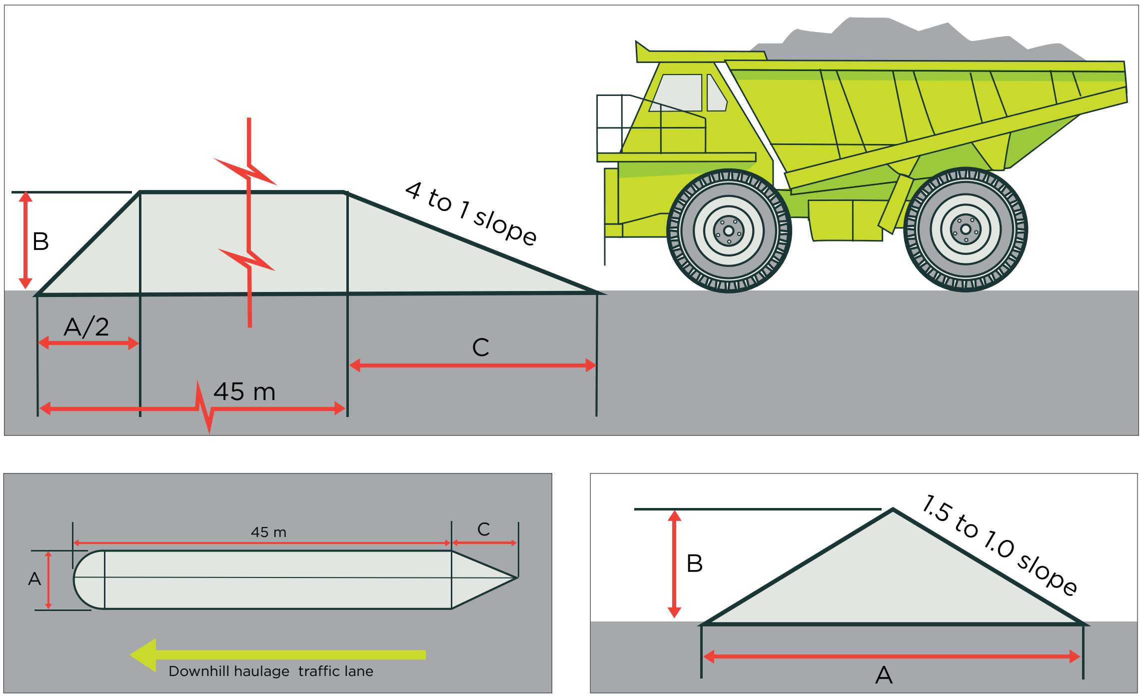
Two types of runaway provision are centre berms and escape lanes.

Centre berms are piles of loose granular material placed strategically along the centreline of the road (refer Figure 29). In the case of brake or retarder failure, the driver manoeuvres the vehicle in line with the berm so the vehicle straddles the berm and is brought to a halt. Consider the following when installing centre berms:

> the nature and size of the equipment that might need to drive on to or straddle the centre bench
> using material to provide sufficient drag on the vehicle
> positioning of the centre berms so vehicles have limited time to pick up momentum
> adequate space between berms to allow the driver time to position the vehicle.

Escape lanes can be used where space is available (refer Figures 30 and 31). Consider the following when installing escape lanes:

> The size and expected speed of a runaway vehicle that might be required to enter the lane.
> Alignment of the lane and the road. An operator of a runaway vehicle should be able to steer the runaway vehicle into the lane.
> Size and length of the lane. The lane needs to be wide enough and of sufficient length to allow vehicle access and time for it to slow and stop.
> Construction material for the lane should offer a high rolling resistance and not tend to compact.




| GROSS VEHICLE WEIGHT | A | B | C |
|---|---|---|---|
| Less than < 45,000 kilograms | 3.5 m | 1 – 1.2 m | 4.5 – 5 m |
| 45,000 to 91,000 kilograms | 3.5 – 4.5 m | 1.2 – 1.5 m | 5 – 6 m |
| 91,000 to 181,000 kilograms | 4.5 – 5.5 m | 1.5 – 1.8 m | 6 – 7 m |
| More than 181,000 kilograms | 5.5 to 10 m | 1.8 – 3.5 m | 7 – 13 m |

**Figure 29:** Runaway-vehicle centre berm

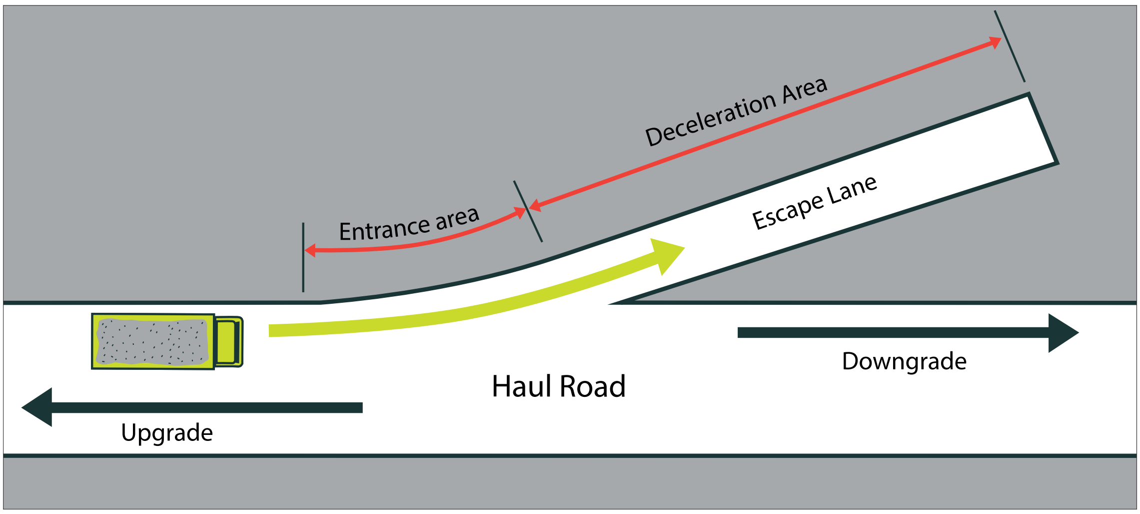



**Figure 30:** Plan view – haul road escape lane

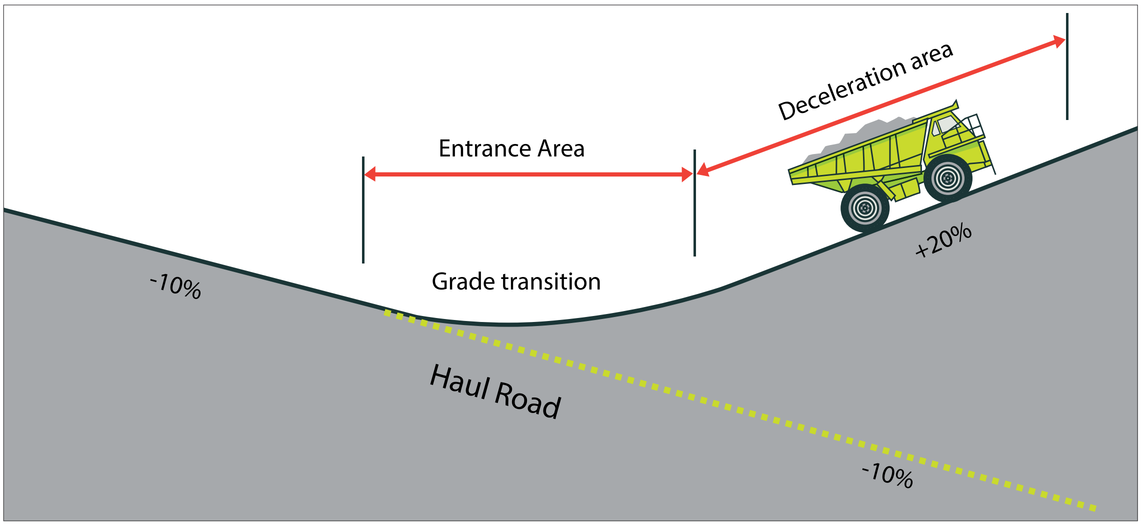



**Figure 31:** Profile view – haul road escape lane

#### 5.3.11 PARKING AREAS

Consider the following when establishing parking areas:

> separating light and heavy vehicles (including private vehicles – eg workers' cars)
> locating on as flat, level ground as possible
> being consistent in design and layout
> where possible, have one way systems (limit need for reversing)
> using stop blocks or spoon drains to prevent unintended movement of vehicles
> managing or limiting pedestrian and light vehicle interaction with heavy vehicles
> having clear signage.

For more detailed information on parking areas, see section 11.3.4.

#### 5.3.12 TIPS OR STOCKPILES

When establishing tips or stockpiles think about the vehicle activities that will occur in these areas and set up controls to manage the risks including:

> ensuring there is sufficient room for vehicles to operate
> where possible, have one way systems
> managing stockpiles so they do not encroach on vehicle operating areas
> managing the size of the stockpile so that it does not restrict lateral vision of operators
> restricting light vehicles and pedestrian access
> providing additional lighting if operating at night.

For more detailed information on tips, see sections 4 and 8.

#### 5.3.13 WORKSHOPS AND FIXED PLANT AREAS

A vehicle collision with a pedestrian, machinery or other vehicle is much more likely in workshops and process plant areas due to the restricted vision around fixed plant and doorways. To reduce the risk of this occurring:

> provide specific parking areas
> restrict vehicle access as much as practicable
> establish clearly identified pedestrian crossings and walkways
> provide bollards or barriers to protect infrastructure close to roads
> establish and sign appropriate speed limits.

### 5.3.14 SLOPE HAZARDS ABOVE AND BELOW ROADS

Road hazards can be created due to instability of material either above or below the road. The hazard from above is for rock falls or slides of material onto the road which could endanger passing vehicles. The hazard from below is that ground will not be stable or have sufficient strength to support the vehicles using the road, especially when roads are constructed on fill areas. You should establish exclusion zones to avoid these hazards.

Pay special attention to the stability of any area where water is seeping out of a slope – the presence of water tends to make slopes less stable. For more detailed information on drainage and depressurisation see section 3.5.5 and 5.3.7.

For more detailed information on slope hazards, see section 3.

#### ROCK FALLS

Where roads are adjacent to any highwalls, slopes or tips containing large rocks, you should make sure vehicles are protected from potential rock falls. Rock slopes tend to become less stable over time due to factors such as weathering and the effects of water. They should be regularly checked for overhangs, open joints or other evidence of unstable rock. Unstable material should be either removed, supported, or the area isolated so drivers are not exposed to a potential rock fall (eg catch berms or rock fall fences).

Consider how high and how far out from the wall the structure must be if using catch berms or rock fall fences. This is to prevent passing vehicles from being exposed to the hazard by absorbing and dissipating the energy of the falling rock. How far a piece of falling rock will come out from a wall depends mainly on the steepness of the wall and the presence and condition of any structures. With a vertical wall, a rock fall would tend to end up near the base of the wall. However, with a sloping wall, or a wall with benches that have accumulations of material on them, the falling material will tend to bounce and be propelled farther out from the base of the wall.

Maintenance regimes should include clearing of slips or rock falls that will reduce the catchment area if left to accumulate.

For more detailed information on ground support, see section 3.

#### CUT AND FILL ROADS

Filled roads should be constructed in compacted, horizontal layers. When fill is placed on an existing slope, the layers should be tied-in by first removing vegetation and cutting horizontal benches into the existing slope material. Any springs or seepage areas should be collected in a drain to prevent the fill from become saturated. Erosion of fill slopes should be repaired before the condition threatens the safety of the road.

Watch for signs the ground below the road may be unstable, such as tension cracks or settling. Slopes may become unstable as they absorb rainfall, become eroded or are loaded by the weight of heavy vehicles.

### 5.3.15 TRAFFIC MANAGEMENT PLAN (TMP)

Regardless of the size of the site, you should produce a site specific TMP to determine where and what risks are present. TMPs are usually documented procedures which are visual in nature and identify vehicle routes, flow, access points, parking areas and other vehicle control areas.

TMPs should be updated to reflect any changes within the operation and communicate these changes to all workers and visitors as required.

This can be effectively achieved by induction, signage or tool box meetings. These will be effective if change management processes are in place.

Roads and other key features of the traffic management system within mining operations must be included in plans[24].

### 5.3.16 TRAFFIC SIGNAGE AND MARKINGS

WorkSafe considers it best practice to use signage (including delineators) and line markings for drivers and pedestrians consistent with those used on public roads (where a suitable sign or marking exists). This is to ensure instructions are easily recognisable to drivers and pedestrians (a learned habit).

For more detailed information on traffic signs and markings see the New Zealand Transport Agency manuals *Ministry of Transport Signs and Markings (MOTSAM), Traffic Control Devices (TCDM) and Code of Practice for Temporary Traffic Management (COPTTM).*

Keep signs clean to make sure they are continually effective. Maintaining signs should form part of the road maintenance programme.

Use illuminated or reflective signs, markings or delineators where driving is likely to be carried out in the dark.

Use delineators suitable for the size of the largest vehicle using the road.

Consider taller delineators (road markers) in snow fall areas to make sure they are always visible where snow can drift or graders may bury them.

Signs could be used to inform drivers or pedestrians about the routes to use and also to instruct people how to behave safely (eg whether they should use protective equipment, and how) (refer Figure 32). Warning signs to show hazards along the way could also be appropriate (refer Figure 33).


**Figure 32:** Example of sign helping arriving drivers know what to expect

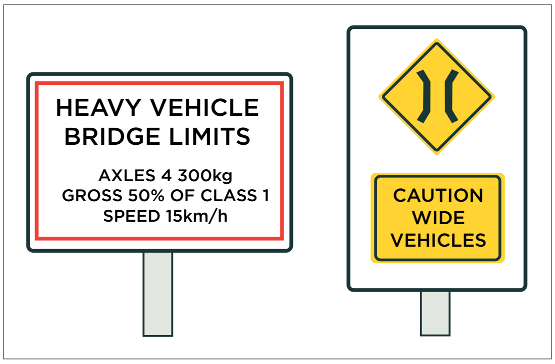



**Figure 33:** Example of weight restriction sign and narrow bridge sign

### 5.3.17 SPEED LIMITS

Speed limits should be established based on the layout and condition of the roads and the capabilities of the vehicles using the roads. For a given section of a road the speed limit should be the speed at which, under normal conditions, sight distances are adequate, the curves can be safely negotiated and any downgrades can be travelled without exceeding the braking capabilities of the vehicles. Additionally, the speed should be

[24] The Regulations, regulation 217 (p)

consistent with the width and smoothness of the road so the driver can operate the vehicle safely and with a reasonable level of comfort and control.

Any such speed limits should be regularly monitored and reviewed to make sure they are still appropriate. Install adequate signage where speed limits are set.

Driving conditions can vary considerably due to:

> changing weather conditions reducing visibility
> general road deterioration (reducing traction or becoming more slippery)
> volume of vehicles which accelerates wear and tear on bends and other areas where braking takes place.

Emphasise to drivers the speed limit only applies under ideal driving conditions, and they are responsible for reducing their speed to a safe level when road, weather, or other conditions are less than ideal. Sites may implement rules for temporary speed limits; for example, under fog conditions speeds are reduced.

For more detailed information on setting speed limits for on-road heavy vehicles, see the New Zealand Transport Agency publication *Heavy Vehicle Stability Guide*.

SPEED ON DOWNHILL SECTIONS

The speed limit posted on downhill sections should take into account the braking capabilities of the vehicles using the road. On haul roads speed limits need to be reduced in advance of a downhill section to account for the lag time involved before retarders are engaged (if fitted). Vehicle operator manuals should be consulted to determine braking capability and retarder lag time requirements.

It is common to have different speed limits for uphill or downhill travel. Signage recommending gear selection may also be required.

SPEED AROUND A BEND

Speed limits around bends can only remain the same as the straight sections of road where the superelevation and radius has been designed to allow this to happen. Where this is not possible, reduce speed limits. Speed limits will need to be sign posted accordingly.

### 5.3.18 LIGHTING

Lighting an extractives site is much more difficult than lighting a public road because of the uneven surfaces and the consequential deceptive effects of shadows.

You must provide adequate lighting to enable workers to move safely around places of work[25]. In addition to vehicle mounted lights, lighting should be provided:

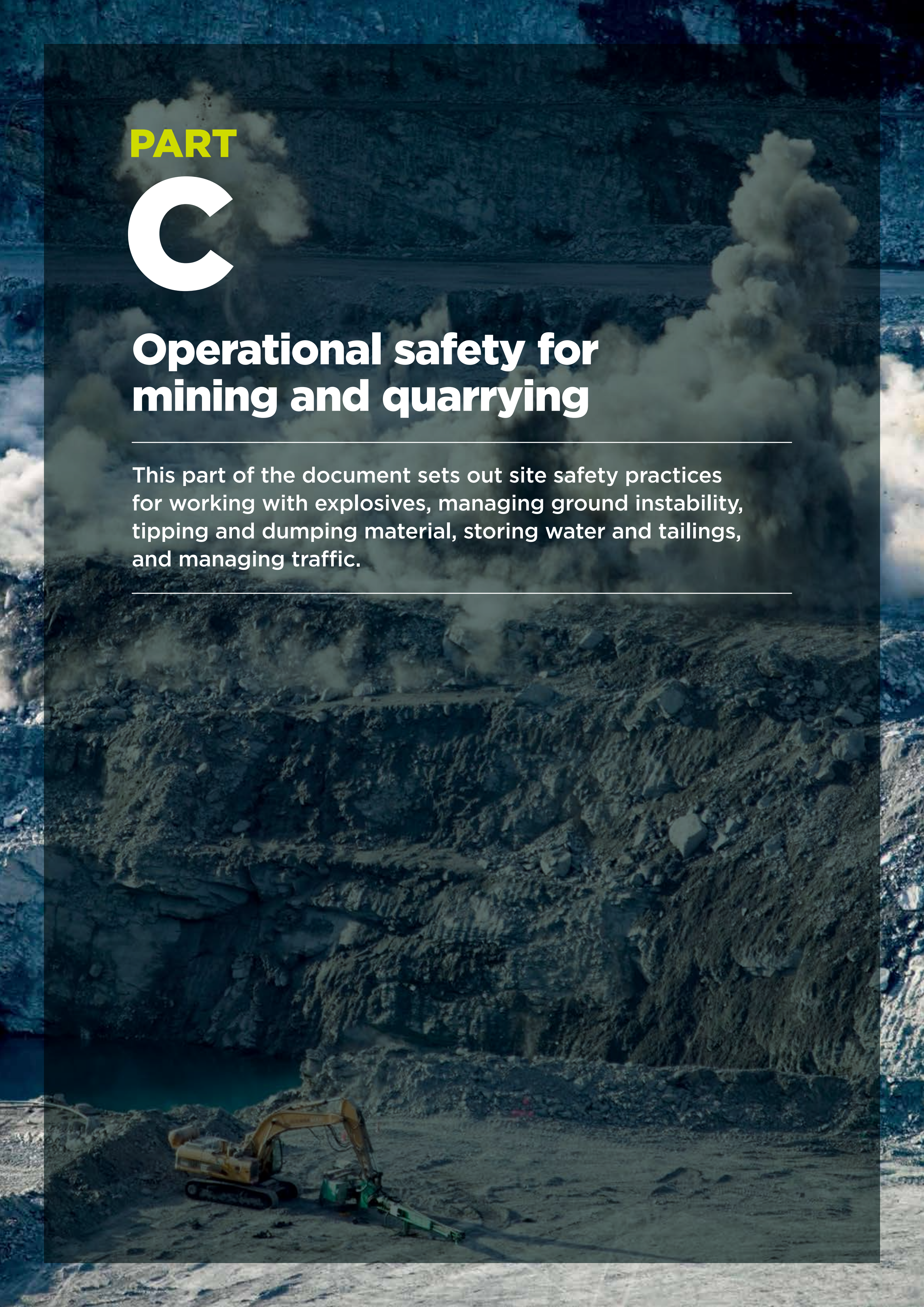
> around plant and buildings
> on pedestrian routes
> where loading and unloading takes place
> at tip points
> at water bodies where access is required to pontoons, pumps, and so on.

Lights provided on vehicles must be sufficient to enable them to be driven safely, but additional lighting may be required for manoeuvring operations such as reversing, dumping, or at intersections.

Lights should be positioned so they do not dazzle the driver when they come around a corner or drive over a crest. When using diesel or petrol powered lighting systems you should make sure they:

> are positioned safely (eg off road lanes)
> have sufficient duration to last the shift without refuelling
> form part of the maintenance schedule.

[25] *Health and Safety in Employment Regulations 1995*, regulation (4) (2) (e)



PART

# C

## Operational safety for mining and quarrying

This part of the document sets out site safety practices for working with explosives, managing ground instability, tipping and dumping material, storing water and tailings, and managing traffic.

PART C

# 06/

# USING EXPLOSIVES

## IN THIS SECTION:

6.1 Hazard management and emergency planning for explosives

6.2 Maintaining, transporting and storing explosives

6.3 Shot firing – safe systems of work

6.4 Explosives selection criteria

6.5 Drilling, charging and blasting

6.6 Post-firing

6.7 Minimising blast damage

**The use of explosives to break rock at a mine or quarry is a hazardous process. The blasting procedure must be managed to protect workers and the general public from the adverse consequences of a blast.**

This section describes:

> how to develop the PHMP, which must cover specific aspects of work with explosives
> risk assessment
> blast design and charging
> how to select explosives
> how to carry out the blast
> safety processes to follow after a blast.

Controls for transport, storage, packaging, manufacture, and disposal of explosives are set under by the *Hazardous Substances and New Organisms Act 1996* and regulations made under that Act (HSNO). The regulations also specify controls to ensure heat, shock, pressure, spark energy and electromagnetic radiation and static energy are safely managed.

There is more information on hazardous substances in section 2.10.

Safe and efficient blasting requires all quarry and mine operators and supervisors to understand and follow correct procedures for handling and using explosives. Practices that lower the risk of premature or inadvertent explosion and prevent the mishandling of explosives are important in maintaining safety.

Any workers handling or using explosives must be competent or strictly supervised by a competent person at all times. Competence should include current relevant qualifications and approved handler certification.

## 6.1 HAZARD MANAGEMENT AND EMERGENCY PLANNING FOR EXPLOSIVES

### 6.1.1 EXPLOSIVES PRINCIPAL HAZARD MANAGEMENT PLAN

Any use of explosives (or associated activities) is considered a principal hazard[26]. Therefore any operation where explosives are used must have an explosives PHMP and an Emergency PCP in relation to explosive emergencies.

Sites where explosives are used must have an appointed manager qualified in accordance with the Regulations[27].

The Explosive PHMP must contain information detailed in regulations 68 and 86 of the Regulations. In summary, regulation 86 includes requirements for information on the following to be included:

> transporting explosives
> explosive precursors
> inspecting, reporting and undertaking actions to ensure safety of explosives and equipment
> accounting for explosives
> checking for deterioration of explosives
> securing and storing of explosives
> identifying and controlling hazards from charging and firing explosives
> declaring danger zones
> finding, recovering and detonating misfired explosives safely

[26] The Regulations, regulation 66 (2) (b)
[27] The Regulations, Part 1, subpart 2

- keeping records of misfires
- keeping a register of approved handlers
- co-operating with explosives contractors or any other person authorised under HSNO regarding storage, handling, transportation and use of explosives.

### 6.1.2 EMERGENCY MANAGEMENT CONTROL PLAN

The Emergency Management Control Plan must contain information detailed in regulation 105 of the Regulations. For information on the Emergency Management Control Plan, see section 17.

Depending on the amount of explosives stored, HSNO requires an emergency response plan. The emergency response plan can be included in your Emergency PCP provided all requirements outlined in the *Hazardous Substances (Emergency Management) Regulations 2001* and regulation 47 of the *Hazardous Substances (Classes 1 to 5 Controls) Regulations 2001* have been addressed.

## 6.2 MAINTAINING, TRANSPORTING AND STORING EXPLOSIVES

All equipment used for shot firing should be checked prior to use and kept and maintained in a safe operating condition. The equipment should be serviced on a regular basis, dependant on the amount of usage and original equipment manufacturers (OEM) recommendations.

> Mining operations must address the inspection and reporting on the safety of shot firing equipment, including how appropriate action will be taken to make the equipment safe, in their explosives PHMP.

### 6.2.1 TRANSPORTING EXPLOSIVES

The person in charge of any transportation of explosives must ensure all requirements listed in regulations 51 and 52 of the *Hazardous Substances (Class 1-5) Regulations* are met as required. These include:

- Notifying the Commercial Vehicles Investigation Unit of the New Zealand Police at least 24 hours before departure on the first occasion of transport by a new route and at intervals no greater than 12 months.
- Making sure there is an approved handler controlling the transportation or the explosives are secured as required by regulation 22 of the *Hazardous Substances (Class 1-5) Regulations.*
- Making sure vehicles meet the requirements of regulations 15, 16, 17 and 21 of the *Hazardous Substances (Class 1-5) Regulations.*
- Making sure there are sufficient of fire extinguishers of the right type.
- Only persons necessary for the transportation or emergency procedures are in the vehicle, but that a minimum of two people are present where quantities are greater than 250 kg.
- Making sure that the amount of explosives transported is within safe load limits.
- Making sure separation distances are maintained and drivers are informed verbally and in writing on the separation distances.
- Making sure vehicles do not stop except where there has been an accident, incident, emergency or need for urgent refuelling or as required by the *Land Transport Act 1998*. Where a vehicle does stop the duration must be minimised. The explosives must be managed according to the requirements for Level 3 emergency management planning as detailed in the *Hazardous Substances (Emergency Management) Regulations 2001.*

Mining operations must address transportation of explosives in their explosives at the mining operation PHMP including inspection and reporting on the safety of equipment and how the equipment used for transportation will be made safe.

#### 6.2.2 STORAGE OF EXPLOSIVES

Explosives must be stored in accordance with *HSNO* and associated regulations[28]. The regulations are supported by the *Approved Code of Practice for Storage of Explosives (HSNOCOP 55)*, which approves aspects of *AS 2187.1-1998 Explosives – Storage, Transport and use Part 1: Storage* for use in New Zealand.

This standard covers:

> requirements for magazines
> segregation and separation distances
> emergencies.

For more detailed information on storage of explosives see the *Approved Code of Practice for Storage of Explosives (HSNOCOP 55)* and *AS 2187.1-1998 Explosives – Storage, transport and use Part 1: Storage.*

Mining operations must address transportation of explosives at the mining operation in their explosives PHMP. Include the inspection and reporting on the safety of equipment for transporting and delivering explosives and the appropriate action to be taken to make safe the equipment used for transporting explosives in the PHMP[29].

#### 6.2.3 TRACKING EXPLOSIVES

Tracking is recording what happens to hazardous substances during their lifecycle from manufacture or import, through distribution, to use and disposal[30].

Explosives must be tracked.

Mining operations must address how explosives brought into and used at the mining operation will be accounted for in their explosives PHMP[31].

#### 6.2.4 SECURITY OF EXPLOSIVES

The *Hazardous Substances (Class 1-5) Regulations* specify the requirements for securing explosives. Explosives must be secured at a hazardous substance location or designated use zone. They must be stored in a container that meets the requirements of either regulation 23 and 24, or regulation 25 of the *Hazardous Substances (Class 1-5) Regulations* unless under the personal control of an approved handler[32].

Mining operations must address the establishment of secure storage for explosives including the system used for signing explosives in and out of storage, in their explosives PHMP[33]. Mining operations must also address inspection of and reporting on the safety of equipment used for storing explosives and how appropriate action will be taken to make safe the equipment being inspected or reported on[34].

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[28] *Hazardous Substances (Class 1-5) Regulations*, regulations 15 to 31
[29] The Regulations, regulations 86 (a), (c) and (d)
[30] *Hazardous Substances (Tracking) Regulations 2001,* Schedule 2
[31] The Regulations, regulation 86 (e)
[32] *Hazardous Substances (Class 1-5) Regulations*, regulation 22
[33] The Regulations, regulation 86 (g)
[34] The Regulations, regulations 86 (c) and (d)

## 6.3 SHOT FIRING – SAFE SYSTEMS OF WORK

You must have safe systems of work in place that take into account your obligations under the HSE Act, HSNO and associated Regulations. Shot firing rules should include:

> hazard identification and checklist for clearing the blast zone prior to final connect up
> clearance distances and suitable shelter for all workers and people in the vicinity
> face checks, edge protection or marking
> storage, transport and security of explosives
> suitable blast warning signals (visible and audible), isolation barriers and signsworkers allowed at the blast site
> protection against unintended initiation and how to deal with misfires.

When controlling and mitigating blast effects (noise, vibration and fumes) mining operations must address the identification and control of hazards that may arise during the charging and firing of explosives and in particular places (eg in a storage bin feeder in which an explosive is to be used to clear a blockage) in their explosives PHMP.

Persons in charge of a hazardous substance location must control adverse effects of unintended initiation in accordance with regulation 31 of the *Hazardous Substances (Class 1-5) Regulations.*

Persons in charge of a detonation of explosives must ensure the requirements of regulation 32 of the *Hazardous Substances (Class 1-5) Regulations* are met.

Ensure there is clarity around the roles and responsibilities for each blast undertaken.

The roles of the blast charger and approved handler in charge of the blast should be appointed by the mine operator.

### 6.3.1 INDIVIDUAL BLAST RISK ASSESSMENT

A formal risk assessment should be completed for each blast, identifying the hazards and controls at each stage, including the extent of the blast exclusion zone during the firing sequence.

Any risk assessment and subsequent hazard controls should be agreed to and approved by all the relevant parties involved in the blasting process before blasting.

Factors to consider during the risk assessment may include (but are not limited to) the following:

Shot considerations:

> the type of shot (cast, stand-up, inter-burden, coal parting, rip rap, protection rock and so on)
> aim of the shot (maximum fragmentation, maximum heave and so on).

Geology of the area:

> the ground type (hardness or bedding planes)
> known geological abnormalities within the blast design area.

Blast design:

> burden and spacing (including blast design)
> average bench height
> vertical location of the bench
> average blast hole load
> the designed blast powder factor
> timing and effects
> equipment and personnel safety
> access to and from the proposed blast declared danger zone
> location of equipment and workers during the blast

> location of protected works or associated works
> location of external infrastructure potentially affected by the blasting activities (buildings, roads, rail).

Environmental considerations

> historical records of fly rock events
> presence of water
> historical or current underground workings
> the formation and management of any blast fume
> radio communication 'black spots'
> the expected weather conditions.

### 6.3.2 BLAST DESIGN

Blast designs will vary from site to site as different types of rock require different types of explosives to be effective. The blast design should be tailored for each blast, in view of the conditions on the site. To achieve success, several site-specific conditions should be evaluated, including:

> the intended slope design
> geology, especially structure and hardness
> water conditions
> vibration characteristics
> pattern shape
> available free faces.

Once these conditions have been defined, a controlled blast design can be developed that takes site factors into account.

The design should:

> make sure any possible fly-rock is contained within the declared blast exclusion zone and include any special precautions required to achieve this (eg blast curtains or blast mats)
> control vibration and air overpressure. This can include limiting the amount of explosive per delay, altering delay timing to suit characteristics and adjusting fragmentation to suit the type of rock and the purpose for which it is intended. For example, blasting for rip rap and large rock is different from a production blast for aggregate
> minimise the risk of misfires
> enable the location of any misfired shots to be determined accurately
> keep back-break to a minimum
> ensure the shape of the muck pile so it can be safely loaded using the equipment at the site.

## 6.4 EXPLOSIVES SELECTION CRITERIA

### 6.4.1 GROUND CONDITIONS

When selecting explosives the objective is to ensure reliability and safety for the ground conditions present.

Modern Ammonium Nitrate based explosives are very safe when handled correctly, they can however explode if subjected to prolonged heating under confinement. Hazardous situations include: dry running or dead heading a pumps, fire encroaching on process equipment or storage areas and contamination by incompatible chemicals.

All blast-holes containing water should be recorded. To avoid the risk of a misfire, wet blast-holes should be charged with an explosive that has appropriate water resistant properties. If damp blast-holes are required to sleep, an explosive with some water resistant properties should be used. Explosives containing sufficiently high levels of emulsion are water resistant and the preferred option for managing damp or wet holes. Use a clear identification system that ensures priming and charging of wet blast-holes is appropriate, for example spray painting the depth of water next to the hole.

### 6.4.2 BLASTING IN OXIDISING OR REACTIVE GROUND

Both sulphide minerals and coal may oxidise rapidly when broken and exposed to air.

In operations where such minerals are present, carry out tests to determine if the ground is reactive.

The explosives to be used and the charging practices to be adopted should be developed in consultation with explosive manufacturers and consider the following general precautions:

> Sheath ANFO explosives to inhibit exothermic reaction between the explosives and the material to be blasted.

> Wash down all exposed surfaces within the blast vicinity to make sure there is no fuel available for a secondary explosion.

> Use adequate stemming in all blast-holes to inhibit the development of a flame front at the collar of a blast-hole.

> Use low explosive strength detonating cord that isn't in contact with rocks or dust (to avoid detonating cord raising and igniting dust).

> Select the correct stemming for the conditions; usually a clay-cock stemming is preferred.

More information is available in the AEISG Code of Practice for Elevated Temperatures and Reactive Ground.

## 6.5 DRILLING, CHARGING AND BLASTING

### 6.5.1 DRILLING BLAST-HOLES

The main risks associated with the drilling of blast-holes are residual explosives from previous blasts being initiated and poorly drilled holes creating an unsafe situation during firing.

Blast geometry and design is imperative to create safe discharges and blast results. Blast-hole diameter, inclination and length should be adequately designed and recorded for the selected drill pattern. Correct drilling of blast designs will ensure safety hazards such as over break, fly rock or air blast overpressure are significantly reduced.

The following standards and procedures should be in place:

> The drilling site should be prepared and drill holes marked before drilling.

> Drilling should not be carried out on any face or bench until it has been examined for misfires and suitably treated (refer to section 6.6.3.2 for the treatment of misfires).

> The driller should record every drill hole including date, time, length, inclination, and position relative to a fixed point or benchmark.

> The driller should record any unusual events during the drilling (eg cavities, soft rock, or an inability to drill designated holes).

> When positioning the drill rig or while drilling near the edge of the bench, the drill rig should be positioned so the operator has a clear view of the edge at all times and far enough away to prevent the drill rig toppling.

> Drilling should not be carried out in a hole where any part is considered within an unacceptable distance from a hole containing explosives.

If it is necessary to drill in or relatively close to an old hole or butt which is suspected of containing explosives, it should only be carried out after the hole has been flushed and a relief hole drilled at a safe distance.

### 6.5.2 CHARGING OPERATIONS

CLEANING AND MEASURING BLAST-HOLES

Blast-holes should be checked before loading to make sure they are clear and drilled to the correct depth. Any blocked holes should be cleared with a charging pole. Blast-holes should have their depth measured and recorded immediately before charging. Short holes can lead to overcharging and digging problems, while overcharged blast-holes can cause fly rock and air blast hazards.

### DISTRIBUTION OF MARKERS AND PRIMERS

Markers should be positioned in a standardised pattern in relation to each hole so when the hole is stemmed, the loader can work in a uniform manner. The marker needs to be securely placed in the drill cuttings so the down lines are not drawn into the hole. Explosive accessories should be distributed and placed alongside the marker near the hole. They should not be placed in the drill cuttings or in a position where a vehicle could possibly run over a primer causing an unplanned explosion.

### PRIMERS

Primer cartridges and the down line used to form the primer should be of suitable explosive strength. The primer should be located in the hole without using undue force and care taken to avoid unnecessary matter between cartridges. The following general precautions should be taken:

> check explosives for damage

> report any damaged explosive to the approved handler to dispose of appropriately

> secure lines to avoid primer being drawn into the hole (slumping)

> place the tails of the down line neatly at the base of the marker so they are secure and away from any vehicle movements

> if a down line or primer is lost down the hole, notify the shot-firer, record the loss and re-prime the hole

> never remove a jammed primer by applying excessive force. Multiple priming should be used if the original primer cannot be removed.

### BULK EXPLOSIVES

When loading free flowing granular explosives and emulsions, avoid damaging down lines or pulling the down line into the hole. The following general precautions should be taken:

> load the shot so the holes furthest from the access point are loaded first

> charge the shot in a way that prevents damage to the down line and excessive spillage around the hole

> regularly sample the product for quality and density to avoid possible desensitisation by compression (dead pressing)

> where the truck empties during the charging of a particular hole, identify the hole and make sure loading is completed before firing.

**Mobile manufacturing unit (MMU)**

The following general precautions should be taken while using MMUs:

> A pre-start check should be conducted to make sure the vehicle is in sound condition and repair.

> All workers operating the MMU must be competent to monitor any support equipment associated with the delivery of the explosives; for example, pump pressure gauges, emergency shut off and so on.

> MMU's must be earthed during mixing and transfer operations to dissipate static charges[35]. This may include electrical continuity through the piping system on the vehicle and fitting of tyres that can conduct static charges.

> The operator should have full view of explosive delivery points or adequate communication with another operator who has a full view.

> Vehicle access to the shot should be by a clearly defined access route designated by the shot-firer.

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[35] *Hazardous Substances (Class 1-5) Regulations*, regulation 18

- In areas of restricted visibility, a spotter should be used to control vehicle movements.
- When working near the edge of the bench hazards must be identified and appropriate fall protection determined.
- Before access to public roads, any explosive residue should be washed with water from pump hoses, explosive mixing receptacles etc.

**Pneumatic charging**

Where pneumatic charging devices are used, they must be effectively earthed. Good practice for operation of a pneumatic charging is for antistatic footwear to be used and for the operators to remove their gloves and earth themselves before touching any electric detonator.

### PREVENTION OF FLY ROCK

Preventing fly rock is vitally important. The main causes of fly rock are:

- The explosives column is brought too high up the shot-hole. The top stemming is less than the burden.
- The rise of explosives has not been checked. Bulk explosive has filled into a cavity, fissure, joint voids or cracks, all of which may have reduced burden and will be over charged.
- Shot holes have deviated when being drilled and have come closer together resulting in a portion of the shot being over charged.
- The drill angle on an inclined shot hole is such that the bottom of the hole has a reduced burden leading to overcharging.
- A section of rock has fallen out of the face after the profiling has been carried out causing a reduced burden which has not been identified and lead to overcharging.
- Poor delay sequences lead to an excessive delay period between adjacent holes resulting in reduced burdens being created during the blasting operation leading to fly rock.
- The amount of explosives placed in the shot-hole is not suitable for the rock type leading to overcharging.
- A geological anomaly in the rock formation, such as a dyke, creates a band of weathered weaker rock in front of a charged shot-hole which can lead to overcharging. Geological anomalies can be difficult to identify as the surface rock exposed on the face will look the same as expected. The drilling could be into competent rock with the dyke located between the shot-hole and the free face.
- Rock around the collar may be fragmented by the blasting of the previous working bench.

Surveying the face, and obtaining as much information as possible on the geology is important when developing blast design. It is also important to verify this information prior to charging the shot holes. Careful adherence to the charging details contained in the blast design should lead to successful, incident free blasting. If some parameters change then the distribution of explosives may need to be altered.

> Approved handlers must ensure no one is subject to any hazardous fragment by limiting the quantity of explosives used[36].

Shot firers should:

- Frequently check (every 2 to 3 metres) the rise of explosives in the shot hole.

[36] *Hazardous Substances (Class 1-5) Regulations*, regulation 34

> Visually check the alignment (azimuth) and inclination of every shot hole and compare them with the design.
> Carefully consider any deviations.
> Consider re-profiling where a rock or slip has occurred after the initial profile was done.
> Include a written delay sequence schedule in the blast specification so excessive delay periods can be easily identified.
> Check the powder factor for the rock type to calculate the quantity of explosives (may wish to compare with previous successful blasts).
> Examine other site faces for evidence of dykes.
> Consult with the driller and check the drillers log for evidence of geological anomalies (eg voids, dykes, clay seams, cavities, fissures, joint voids or cracks). Also check for changes in the rate of penetration of the drill string (if it increases it can be due to weaker rock).
> Consider increasing the top stem where rock around the collar has been fragmented by blasting of the previous working bench.

#### SLEEP TIME IN BLAST-HOLES

The sleep time of an explosive is important because explosives can often deteriorate under unfavourable conditions such as heat, cold, humidity and water and could cause failure of the explosives. Product deterioration may result in a charge, or part of a charge, failing to explode or misfiring. Explosives should be charged and fired at the earliest practicable time.

At any time when a blast is being slept, guards should be posted and remain in place until the blast is fired.

#### CHARGING DURING SHIFT CHANGES

When charging is being done during shift changes, a written procedure should be in place for communication between the shifts. Information about charging and blasted locations, holes loaded and any unique hazards or unusual circumstances associated with the shot should be shared.

#### PERSONAL PROTECTIVE EQUIPMENT (PPE)

When handling or using explosives, the potential hazards must be identified and suitable PPE provided and worn. Safety Data Sheets for the products being used will outline PPE requirements. These may include retarding clothing, gloves, goggles and in some instances, anti-static clothing.

#### ACTIVITIES IN PROXIMITY

There must not be any activity undertaken within the proximity of the shot that could generate heat, sparks, an impact or pressure shock that could result in an explosion or fire[37]. This includes smoking, naked flames or operation of machinery. Unauthorised workers and machinery not involved in the blasting operation should be removed a safe distance from the area.

#### VEHICLES ON NON-ELECTRIC BLAST

Where vehicles are used at non-electric blasts there is a risk of a premature explosion or misfire if the vehicles run over detonators or damage the signal tube. Vehicle access to the shot should be by a clearly defined access route. Where there is restricted visibility a spotter should be used to control vehicle movements.

#### SIGNAGE

Charging areas should be clearly marked by appropriate warning signs. Where charged holes will be left to sleep over night suitable

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[37] *Hazardous Substances (Class 1-5) Regulations*, regulations 15, 16 and 17

barricades, warning signs and lighting should be used. Approaching vehicles and people need to be able to clearly identify the charge area. If further warning is required an overnight guard can be utilised to direct people and vehicles around the shot area.

COMMUNICATION DEVICES

When using electric initiation it is possible for the blasting circuit to be energised by the electric field produced by radio transmitters, mobile telephones, two way radios and so on. Safe distances for electric detonators subject to radio frequency should be determined. Such devices should never be carried while holding or connecting electric explosives.

#### 6.5.3 STEMMING

Avoid damaging the down line connected to the primer during the placing of stemming material. The following precautions should be taken:

> Make sure the hole has been loaded with explosives and the collar length is correct.
> Check the tension on the down lines to determine whether the primers are in the product.
> Check the stemming material is of a suitable quality and does not contain large fragments of rock that may cause damage to down lines.
> Approach the hole from the side opposite to the marker securing the initiating line if loading with mobile equipment (refer section 6.5.3.2).
> Leave blast-holes charged with gassed bulk explosives un-stemmed for the recommended time to allow for gas bubble expansion.
> Stem all loaded holes prior to the end of the shift. In cases where this is not possible consider blocking the hole with a gasbag or covering it with drill cuttings.

TAMPING RODS

Only wooden or other non-metallic rods should be used when tamping to prevent the possibility of an explosion from shock, friction or impact. Make sure the safety fuse, lead wires, detonating cord or signal tube connected to the primer are not damaged during the tamping process. A primer should never be tamped due to the risk of explosion caused by impact.

STEMMING HOPPERS

Where mobile equipment is used to carry a hopper for the loading of stemming into charged holes the mobile equipment should have good visibility. Care should be taken not to damage down lines on charged holes. Stemming should be completed as soon as possible.

#### 6.5.4 INITIATION

Consider the following procedures when connecting shots using non-electric, detonating cord or electric initiated systems:

> Workers carrying out the hook-up should have a connection plan.
> After connecting the shot it should be checked to confirm it is correct. The approved handler is ultimately responsible for the hook-up and should personally check the connections before firing.
> The system for firing the explosive must not be readied to the point that only the one final action needs to be taken to fire the charge until all safety requirements; including clearing the blast area, has been done[38].
> In the event of a possible thunderstorm developing, the person in charge must assess the proximity of the storm and decide whether to fire or not. If a thunderstorm approaches any handling or preparation of the explosives must

[38] *Hazardous Substances (Class 1-5) Regulations*, regulation 33 (1) (e)

stop and all people evacuated in accordance with section 33 of the *Hazardous Substances (Class 1-5) Regulations*. Where a shot is not going to be fired, the shot-firer should disconnect the control row before evacuating, if safe to do so.

### NON-ELECTRIC FIRING

A procedure should be in place that provides a safe system of hook-up on non-electric explosives. Connections and detonating cord charge weight (grams of explosives per metre) should be in accordance with manufacturer's instructions.

### ELECTRIC FIRING

> Electric detonators are susceptible to accidental initiation by sources of stray electricity. To reduce the risk of accidental ignition the following controls should be applied. Keep wire ends, connectors and fittings, shorted (twisted) until immediately prior to use.

> Do not use electric detonators near power lines or other potential sources of electric current.

> Stop all surface charging operations if an electrical storm is imminent. Lightning detector devices can be used to track storms and lightning strikes, giving greater determination of whether surface charging operations should be stopped. Select an appropriate detector for the type of charging operation, and use in accordance with site and manufacturer's instructions.

> Keep detonators clear of the ground until charging starts.

> Never hold an electronic delay detonator while it is being tested or programmed.

> Do not use plastic liners in blast-holes unless they are permanently conductive.

*Hazardous Substances (Class 1-5) Regulations, regulation 19: Protection from stray electrical currents:*

Where any class 1 substance is to be fired using an electrical system other than those firing systems initiated only by electrical currents modulated to specific waveforms or pulse sequences, the area within 2 metres of the uninsulated portion of the electrical firing system must not be subject to stray electrical currents of more than 60 mA.

*Hazardous Substances (Class 1-5) Regulations, regulation 20: Protection from electromagnetic radiation:*

When undertaking any electric firing in close proximity to radio masts or antennae, cell towers, communications towers or satellite dishes, the requirements of regulation 20 must be considered before the blast is designed. Alternatives would be to use non-electronic blasting methods.

### CIRCUIT TESTERS

Before connecting the firing circuit, the detonating circuit and firing circuit should be checked to ensure continuity. It is possible an explosion might occur when testing. Therefore appropriate hazard controls, including clearing the blasting area and choosing a safe location for testing, must be in place. The shot-firer should make sure the circuit tester is maintained in correct working order.

### SHOT FIRING CABLE

Where a shot firing cable is used to initiate a blast, the shot-firer should make sure the cable is adequately protected and insulated for the conditions under which the blasting is to be carried out. Adequate precautions are essential to prevent the cable from coming into contact with electrical installations, metal objects and areas where possible damage can be caused to the insulating cover.

Keep the cable short-circuited at each end during the charging operation and at the power end while the leads from the detonators are being connected. The short circuit at the power end should not be opened for connection to the source power until the blasting area is clear of people. As soon as the blast has been fired the short circuit should be re-established by physical disconnection from the exploder.

EXPLODERS

Only exploders capable of storing or generating the electrical energy required to reliably initiate electric detonators should be used. They should be carefully handled and regularly tested to ensure reliable performance.

*Hazardous Substances (Class 1-5) Regulations, regulations 15 to 18:*
Explosives must not be:

> Subject to any impact or pressure shock that could result in an unintended explosion or fire.
> Exposed to any ignition source that may release spark energy in a way that could result in an unintended explosion or fire.
> Exposed to any ignition source capable of generating heat or fire where that could result in an unintended explosion or fire.
> Exposed to the build-up of static electrical charges where that could result in an unintended explosion or fire.

### 6.5.5 FIRING

BLAST EXCLUSION ZONE

The shot-firer should determine the blast exclusion zone and the location of guards by undertaking a risk assessment which considers any technical concerns or known hazards in the shot.

The approved handler must ensure no person is subject to blast overpressure, heat radiation, ground vibration or hazardous fragments as described in regulation 34 of the *Hazardous Substances (Class 1-5) Regulations.*

WARNING PROCEDURES

The person in charge of the detonation must ensure everyone not specifically authorised by the approved handler to be in the designated use zone are excluded, using the following methods:

(a) Information must be displayed that—
  (i) Warns that a substance is being detonated and that entry is prohibited; and
  (ii) is visible from all points that are 5 m from the outer side of the perimeter of the designated use zone; and
  (iii) meets the level of comprehensibility and clarity required for signage in Part 3 of the *Hazardous Substances (Identification) Regulations 2001;* and
(b) 1 minute before firing, a distinctive warning sound must be generated that is of sufficient volume to be heard throughout the zone, and at all points that are 5 m from the outer side of the perimeter of the zone, by a person with normal hearing; and
(c) a visual check must be made of the zone immediately before firing to ensure that all people not directly involved with the firing have been excluded[39].

**External parties**

Pre-notify external parties if necessary before conducting blasts. External parties may include adjoining properties, residences or the general public.

[39] *Hazardous Substances (Class 1-5) Regulations*, regulation 32

**Withdrawal of people**

People in the vicinity of the blasting area must be warned and withdrawn to a safe area outside the blast exclusion zone before firing the shot. They should not return until the 'all clear' signal is given. Everyone involved in the blast must be able to reach a predetermined safe position before firing.

A visual check of the blast exclusion zone must be undertaken prior to firing.

**Signage**

Information must be displayed that warns people there will be a blast and that entry is prohibited. Any signs must be clearly visible and written in such a way that people can clearly understand them.

**Audible warning device**

An audible warning device must be used to indicate a blast is going to take place. The device must produce a sound that is clearly identifiable from any other sound which might be used for warning or operational signals on the site. It must be loud enough to be heard throughout the blast zone and at least 5 metres from the blast exclusion zone perimeter.

**Radio Signal**

Where radios are also used to give an audible warning signal, everyone on site should clearly understand the implication of the warning signal.

Where there is more than one radio channel used on a site, select a radio channel that is always used for blasting. The warning signal should be broadcast simultaneously on all channels where there are users of other channels in the blast locality.

**Preventing access to the blast exclusion zone**

Adequate roadblocks and guards should be placed at any road or access point in to the blast exclusion zone during the firing and until the all clear is given by the shot-firer.

BLAST MONITORING

Where blasting is conducted in close proximity to buildings or structures, ground vibration and air-blast overpressure should be monitored to record the blast characteristics.

The approved handler must ensure the firing is monitored[40].

## 6.6 POST-FIRING

### 6.6.1 POST-FIRING INSPECTION

A post-firing inspection should be undertaken. Before entering the blast area, sufficient time must be allowed for dust and fumes to clear. Early re-entry may result in illness from inhalation of toxic gases and post-blast fumes. Dust and fumes can also reduce visibility and result in collisions, falling, tripping or inability to detect unstable rock.

Where a blast has been initiated by electric detonators, the firing cable should be disconnected from the exploder immediately after firing and before the post-firing inspection. The ends of the firing cable should be short-circuited together, and the key removed from the exploder.

The purpose of a post-firing inspection is to confirm conditions in the area of the blast are safe for work to restart. In particular, the shot-firer should look for evidence of:

> **Unstable ground**: The vibration, concussion and ground stress redistribution resulting from blasts can loosen rock around walls located some distance from the blast site. Areas that were stable before a blast can become unsafe or collapse after a blast, particularly large blasts. Falls of ground can pose a serious threat to the safety of any workers in the area. People undertaking the post-blast inspection should approach the blast area with caution, avoiding the toe and crest of the face. If possible inspect the blast muck-pile from the bench below or to the side.

[40] *Hazardous Substances (Class 1-5) Regulations*, regulation 33 (1) (f)

> **Misfires or burning explosives**: If explosives have misfired or are burning there is a clear danger of additional detonations with the associated risks of blast damage and fly rock. Misfired explosives are often difficult to detect and accidental initiation in a confined location can cause fatal or serious injury. It is essential to thoroughly look for any signs of misfired detonators, detonating cords and burning explosives during the post-firing inspection and all subsequent mucking operations. People in the area should immediately return to a designated safe zone if misfires or burning explosives are discovered. The all clear should not be given and all guards, barricades and signage should stay in-place. The approved handler should inform the quarry or mine manager of the situation immediately.

Only after the post-firing inspection has been completed and the area has been confirmed as safe, should the all clear can be given and barricades, cautionary signs and guards removed.

The approved handler must ensure any misfired charge is identified[41].

### 6.6.2 PREVENTION AND MANAGEMENT OF POST-FIRING FUMES

Blasting operations can sometimes cause toxic gases, including oxides of nitrogen, ammonia, nitric acid, carbon monoxide and carbon dioxide, to be released into the atmosphere in significant quantities. These gases are often referred to as blast fumes and exposure to even quite low concentrations can pose a serious health risk. Nitrogen dioxide is visible as a reddish brown colour; the others are not visible.

Safety management systems should include the different control phases for blast fumes which include:

> prevention: how to prevent or minimise blast fumes

> management of fumes: where blast fumes extend beyond the blast exclusion zone

> management of an exposure: for when people are exposed to blast fumes.

Mining operations should include control measures in their Explosives PHMP and Emergency PCP.

PREVENTION

There is a strong correlation between wet ground and the production of excessive blast fumes. As well as water, known causes for the generation of blast fumes are:

> incorrect fuel to oxygen ratio

> product pre-compression

> insufficient priming

> acidic soils

> presence of pyrite

> product formulation.

Blast fumes can be reduced if:

> the explosive product selected is correct for the conditions

> holes are dewatered before loading

> sleep times are kept to the minimum time recommended by the manufacturer.

An understanding and application of meteorology (ie weather conditions, wind speed and direction and stability classes) and gas cloud distributions will enable calculation of how long a blast gas plume will take to reach a point of interest such as a smoko hut, workshop, office or house[42]. Such understanding and application also helps in determining the dispersion of the gas plume, how far it will spread sideways, and how the gas concentration will change with distance. Anyone developing prevention and emergency management plans should understand the gas toxicology and the

[41] *Hazardous Substances (Class 1-5) Regulations*, regulation 33 (1) (f)

[42] Buildings should not be used as shelters unless they have been assessed by competent persons as safe havens

exposure standards of a gas (ie nitrogen dioxide) particularly high concentration exposures over relatively short periods.

MANAGEMENT OF FUMES

Before a gas plume occurs, it is important to have a system for managing a potential incident including evacuations. The system should include information on wind speed and direction and on whether there is a gas-tight shelter nearby. Communication systems and monitors to record concentrations of toxic fumes should also be in place.

MANAGEMENT OF AN EXPOSURE

Exposure to nitrogen dioxide can result in delayed health effects that may be life-threatening even though the exposed person may initially appear relatively unaffected. For this reason, people who have been exposed to nitrogen dioxide should undergo an immediate medical assessment and a continued period of observation on the advice of the treating doctor. It is recommended that as a precaution the patient be observed for up to 12 hours.

Safety data sheets relative to the types of products being used should be readily available to everyone involved in the blasting process.

Source: Queensland Department of Employment, Economic Development and Innovation, Explosives Inspectorate, Safety Alert No. 44 V2, 15 March 2011 *Prevention and management of blast fumes*.

### 6.6.3 MISFIRES

The site should have a written procedure that provides a safe system of entry and inspection for misfires and their treatment including the methods used for detecting a misfire.

> Mining operations must address the procedure to find, recover, and detonate misfired explosives and records to be kept of misfired explosives in their explosives PHMP[43].

> The approved handler must ensure any misfired charge is identified[44].

DETERMINATION OF MISFIRES

Methods used to determine if a misfire has occurred are based on many factors, including appropriate training, standard operating procedures and guidance from standards (eg *AS 2187.2-2006 Explosives – Storage and Use*). There are certain events that indicate a misfire has occurred including:

- If using safety fuse, the number of shots counted is less than the number of holes fired or a disagreement on the count of shots fired.
- If damaged safety fuse, detonating cord, lead wires or unfired signal tube is exposed in a hole that has been fired.
- Evidence of cut-offs, butts or remaining portions of holes (eg boulders with drill holes) that are suspected of containing explosives.
- Holes that have slumped between charging and firing due to dispersion of the explosive from water ingress or through joints and fissures.
- If during the normal excavation of the blasted ground, uninitiated or residual explosives are found or the load out mobile plant encounters poor 'diggability' of the blasted ground.

A careful examination of the debris for explosives must be undertaken which, if present should be safely disposed of (refer section 6.6.6).

MISFIRE TREATMENT

Having located a misfire, do not attempt to drill into the charged hole. A hazard identification and risk assessment should be undertaken to determine the safe treatment method. A misfire among a number of charges may cause excessive rock scatter when fired

[43] The Regulations, regulations 86 (k) and (l)

[44] *Hazardous Substances (Class 1-5 Controls) Regulations 2001*, regulation 33 (1) (f)

because the successful shots have relieved the overburden. Adequate extra cover should be used in such cases.

**Removal of stemming and re-priming**

Where a hole has completely misfired, the stemming may be removed by either applying water under pressure or by compressed air and water through a length of antistatic hose (ie FRAS). No metal fitting should be within the hole. Where water under pressure (or water and air pressure) is not available the stemming may be "sludged" out using water and a wooden or other approved implement. Compressed air alone should not be used.

When the stemming has been removed a fresh priming cartridge may be inserted and the hole again stemmed and fired. An artificial burden or cover should be placed around and over the hole to prevent fly rock.

If a misfire contains ANFO or slurry or any other explosive rapidly destroyed by water, such explosive may be "sludged" out down to the primer using the procedure described for removal of stemming above. The slurry explosive washed out should be treated as deteriorated explosives and dealt with as detailed in section 8.21. The hole should then be re-primed and fired to explode the original primer. Do not remove a primed charge from the blast hole.

**Relieving hole misfire treatment**

Where it is not possible to explode a misfire by re-firing a relieving hole should be drilled parallel to the original hole then charged and exploded as follows:

> Mark the misfired hole clearly or block it by inserting a wooden plug.

> When the misfired hole is 50 mm or less in diameter and less than 3 m in length, do not drill the relieving hole closer than 600 mm to the nearest point of the misfired hole.

> When the misfired hole is larger or longer than 50 mm and 3 m respectively, increase the distance between the misfired hole and the relieving hole so the misfired charge will not be drilled into.

> When an electric detonator is involved, first short-circuit the detonator wires and then tie to some permanent object to recover the detonator after a relieving hole has been fired.

All explosives recovered from misfired holes should be collected and disposed of as detailed in section 6.6.6.

**Shattered ground**

If the ground around the misfire has been shattered the relieving hole method should not be used. In this case the ground around the misfire should be carefully cleared until the explosives are uncovered. Do this cautiously by following the wires or fuses down to the charge, removing the last few inches of cover by hand.

**Pre-drilling precautions**

No hole should be drilled in any face or bench until it has been thoroughly cleaned and washed down within a radius of 1 m from the intended hole. Any cut-offs or sub-drill holes should be examined to make sure they do not contain explosives. Sub-drill holes should then be plugged with a wooden plug. If examination reveals explosives the cut-offs or sub-drill holes should be primed and fired and the pre-drilling precautions above taken again.

**Misfire workers**

Where a misfired charge is identified the approved handler must ensure no-one approaches for 10 minutes in the case of an electrically fired charge. For a charge fired by a fuse[45] this is 60 minutes. The approved handler must then safely depose of the malfunctioning charge in accordance with regulation 5 of the *Hazardous Substances (Disposal) Regulations 2001*.

[45] *Hazardous Substances (Class 1-5 Controls) Regulations 2001*, regulation 33(1A)

The approved handler may have an experienced person to assist. All other people must be kept well clear of the area.

The person in charge must ensure the requirements of regulation 32(3) of the *Hazardous Substances (Class 1-5) Regulations* are maintained until safe disposal by the approved handler is completed. This includes display of information, warning sounds and visual checks.

LOADING OUT A KNOWN MISFIRE

Before retrieving misfired material, a written hazard identification and risk assessment should be completed by competent people. The hazard identification and risk assessment should take into account the site shot firing procedures. The hazard identification and risk assessment should identify key areas, for example:

> The excavator involved may need to be provided with additional protection for the operator. This depends on the properties of the material involved.
> Use CCTV or other suitable means of isolation, to observe the muck pile during the loading operation so the mobile plant operator can be alerted to the presence of suspect material.
> How shot holes involved in the misfire can be located in the muck pile. Survey equipment may be used which can more accurately define the hazardous area. Flags, bunting or warning notices may be needed to mark the areas identified.

Accidental initiation can occur while the mobile plant operator recovers explosive material by:

> the bucket of the mobile plant striking the explosive material during excavating
> rock falling and striking the explosive material
> the mobile plant running over the explosive material
> movement of rock in the bucket while transportation is taking place
> tipping the rock out of the bucket at the search site.

All explosive materials have a sensitivity, some greater than others. Heat, pressure and friction can initiate the explosives or detonators especially if they are damaged. When misfired charges are found the approved handler must safely dispose of them. For more information on disposal of defective explosives see 6.6.6.

### 6.6.4 RECORDS

Blasting records including all key parameters such as hole specification, burden and spacing, quantities of explosive used, tie-in pattern and number of delays should be documented.

### 6.6.5 REPORTING REQUIREMENTS

The approved handler must report all misfires to the person in charge[46].

Misfires and other explosive incidents[47] must be reported to WorkSafe in accordance with Schedule 7 of the Regulations.

### 6.6.6 DISPOSAL OF SURPLUS AND DEFECTIVE EXPLOSIVES AND PACKAGING

The disposal of explosives is considered to be an inherently hazardous task. There have been a number of fatalities and serious injuries where people have attempted to dispose of explosives themselves. Disposal of explosives must only be done by fully trained, competent people with specialist experience in this field.

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[46] *Hazardous Substances (Class 1-5 Controls) Regulations 2001,* regulation 33(1A)(b)
[47] As defined by Schedule 8 of the Regulations

### EXPLOSIVES NO LONGER REQUIRED

Explosives no longer required should be returned to the supplier. Where they cannot be returned to the supplier, disposal methods must be in accordance with regulation 5 of the *Hazardous Substances (Disposal) Regulations 2001*. Explosives must not be thrown away, buried or flushed.

### EXPLOSIVES FOUND WHILE LOADING

Treat any suspected explosives found while excavating as live. Shut the area down, set up a prohibited zone and put control systems in place, including informing the site manager (Quarry Manager or Mine Manager).

### DETERIORATED AND DEFECTIVE EXPLOSIVES

The Government funds a free collection service for the disposal of deteriorated and defective explosives which is conducted by Civilian Ammunition Inspectors and the New Zealand Defence Force. To arrange for the collection and disposal of deteriorated or defective explosives contact your local Police station in the first instance (do not dial 111).

Deteriorated and defective explosives include:

> explosives with an expired shelf life
> any explosives recovered through a misfire procedure
> any explosives that are found to be in damaged condition.

### EXPLOSIVES PACKAGING

Empty explosive packaging should be checked to ensure no explosive remains hidden or lodged within any packaging before disposal. Labels should be clearly marked so there is no uncertainty of the packaging contents.

### DISPOSAL OF EMPTY EXPLOSIVE CASES

Disposal of empty explosives cases must comply with regulation 10 of the *Hazardous Substances (Disposal) Regulations 2001.*

Where burning empty cases following a blast, they should be taken away from the blast site to a secure place. After checking no explosive remains hidden or lodged in the case and any residual content is removed, burn them under controlled conditions. The site should be cleared and secured while the burning takes place. The area should be checked after burning to make sure there is nothing left of the cases.

## 6.7 MINIMISING BLAST DAMAGE

Inappropriate blasting practices can result in substantial damage to the rock mass in the interim and final slopes. The consequences of poor blasting practices include:

> Loose rock on slope faces and batter crests.
> Over-break in the face leading to over-steepening of the slope, which in turn could lead to further instability depending on the level of stability allowed in the original design.
> Sub-grade damage that can destroy safety benches leading to a reduction in their effectiveness as a means of retention of loose rock pieces falling from above.
> A cumulative reduction in the strength of rock mass in which the slope is developed. In particular, the shear strength of the structural defects will be reduced.

Consequently, put in place standardised drilling and blasting practices based on well-founded and recognised blast design procedures, which are appropriate to the ground conditions at the site.

PART C

# 07/

# CONTROLLING GROUND INSTABILITY IN EXCAVATIONS

## IN THIS SECTION:


7.1 Planning and design

7.2 Excavation rules

7.3 Excavation control and scaling

7.4 Slope movement monitoring programs

7.5 Remedial measures

7.6 Historic underground workings

7.7 Working near slopes

## To manage the risk of ground instability during excavation, have suitable procedures in place for excavation and monitoring of slopes.

This section describes how to:

> scale and control excavations to prevent rockfall or slope instability
> monitor slopes to detect any instability
> prevent or put right ground instability
> excavate safely under water.

### 7.1 PLANNING AND DESIGN

Before any excavation begins, an appraisal of the site ground conditions should be undertaken by a competent person to determine all factors likely to affect the stability of the ground and the limitations that should be imposed on the excavation site design.

This should be documented. The assessment should be reviewed and revised where necessary when a material change has occurred in the ground conditions or the excavation methods. Effective ground control relies on geotechnical information obtained at different stages of the life of the site – during planning and design, at implementation of the design and through day-to-day operations such as surveying, installation, maintenance and inspections.

Following appraisal of ground conditions, a design should be prepared setting out the measures to control ground instability. Where an existing design has already been proved, it may be used as the basis for the design of a new excavation, if the ground conditions at both sites are not significantly different.

During planning and design, there is usually a relative lack of data available when the slope design is first developed. It is therefore essential geotechnical information obtained during operations is consolidated with information in the geotechnical model and continually used to assess the suitability of the slope design in relation to ground stability.

Implementing the design typically involves considering suitable ground control strategies, such as minimising unnecessary damage to slopes during blasting, excavation control and scaling, and installation of ground support and reinforcement.

Refer to Section 3 for more information on excavation design.

### 7.2 EXCAVATION RULES

Excavation rules should be drawn up setting out:

> the manner in which excavation activities should be carried out, specifying the type and reach of excavators
> the physical dimensions of the excavation including slope, height of faces, width of benches, position of catch-berms and gradient, position and protection of access ramps
> the way in which material should be removed from the excavation
> the sequence in which material should be removed
> maintenance of faces including scaling
> the nature and frequency of supervision
> response to defects.

These rules are essential for the proper management of excavations. They are practical measures required to keep excavations and the people working in and around them safe.

## 7.3 EXCAVATION CONTROL AND SCALING

Adequate excavation control and scaling of faces (and selection of the equipment to be used to achieve the desired standards) are critical elements in achieving and maintaining safe slopes.

In soils and weak and weathered rock, batters can be excavated by free digging using hydraulic excavators. It is critical slopes are not under-cut so the as-built slope is steeper than the as-designed slope as it could result in instability. Provide adequate surface runoff control measures to the benches separating the batters to minimise water infiltration and slope erosion.

In strong rocks, drilling and blasting is needed to fragment the rock mass prior to the final preparation of the slope. Care should be taken to prevent over digging of the face, particularly where there is blast damage or fractured rock.

Scaling of the batter crest and face following excavation is an important component of the implementation of the design. Scaling is intended to remove loose blocks and slabs that may form rock falls or small failures. Scaling also helps preserve the catch capacity of benches needed to retain loose rock material rilling from above. In soils and weak and weathered rock, experienced mobile plant operators can construct slopes with smooth surfaces so scaling is not generally required.

Scaling from the bench above is normally done by chaining the face using a large chain (ship's anchor chain) with or without attached dozer track plates. The chain can be dragged along the face by a dozer or backhoe. Do not use a backhoe to scale the face from the bench above, as large rocks may pull the plant off balance.

Scaling from the bench below is generally performed by an excavator configured as a backhoe. Most manufacturers offer specialised units equipped with long booms holding small buckets or rock picks.

The debris accumulated at the toe of the batter after scaling should be removed before access to the toe is lost. This will ensure adequate catchment volume on the safety bench is maintained. Supplementary bench cleaning will depend on access and the service life of a slope. Periodic bench inspections should identity sections that require cleaning.

### 7.3.1 MOBILE PLANT WORKING ON FACES

Faces that have potential for instability should be worked within the reach height of the equipment used, whether they are working in sand or hard rock. Typically, wheel loaders can reach 6-8 m and excavators 9-12 m. Larger mining shovels (120 tonne or more) are capable of reaching 18-20 m depending on how they are used.

If mobile plant is at risk of being engulfed in a face collapse, a trench or rock trap should be used to maintain a safe operating distance.

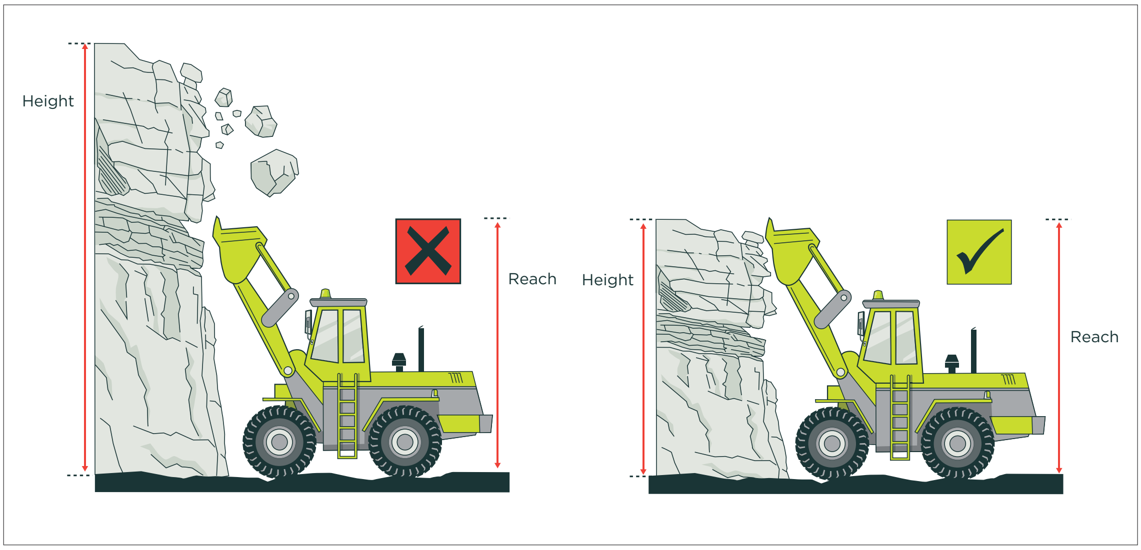


**Figure 34:** Face height should not exceed the reach of the loader used on the face

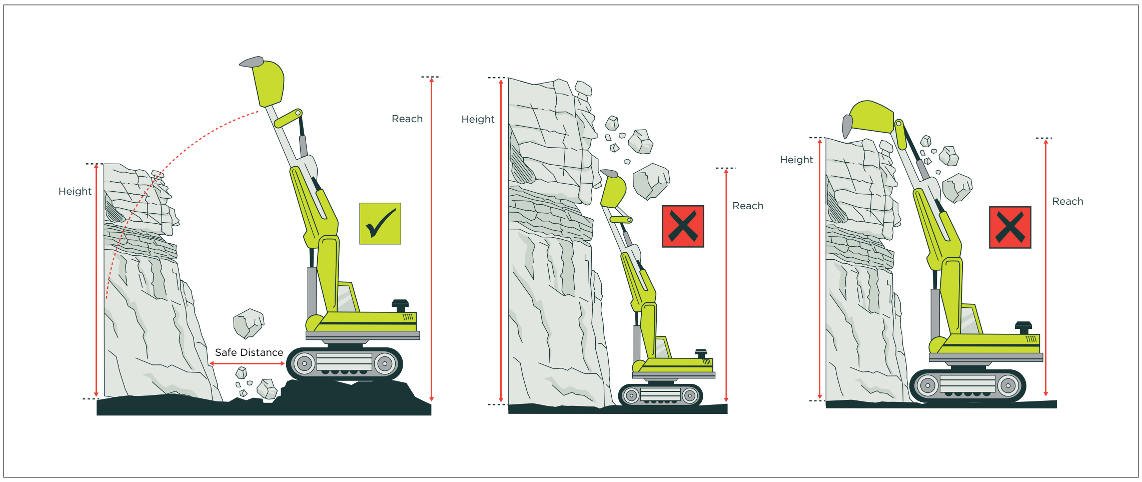


**Figure 35:** Face height should not exceed the reach of the excavator used on the face, with safe operating distances

### 7.3.2 POST EXCAVATION INSPECTION OF BLASTED SECTIONS[48]

When the excavator reaches the batter face following a blast, the designed toe and crest should be achieved and no blast-induced damage should be visible of the face. After excavation is completed the face should be inspected and analysed for excessive over break. The damage should be classified into the following categories to help guide design refinement.

> No visible damage: joints tight, teeth marks in face, no loose material present, half-barrels visible when pre-splitting and a well-defined toe and crest.

> Sight damage: joints opened up, crest loss <1 metre, few half-barrels visible when pre-splitting, excavation possible for 1 metre beyond designed batter location.

[48] Source: Beale G. (2009) Guidelines for Open Pit Slope Design, Eds. John Read and Peter Stacey, CSIRO Publishing

> Moderate damage: blocks dislodged, crest loss 1-3 metres, excavation possible for 1-3 metres beyond designed limit.
> Severe damage: face shattered, blocks dislodged and rotated, excavation possible for more than 2 metres from designed limit.

A detailed record should be made of the post excavation performance of the batter face.

### 7.3.3 INDICATIONS OF FAILURE[49]

Even the most carefully designed slopes may be subject to instability. Some of the more common indications of failure are listed below.

#### TENSION CRACKS

Cracks forming at the top of a slope are an obvious sign of instability. Cracks form when slope material has moved toward the floor. Since this displacement cannot be detected from the floor, it is extremely important to frequently inspect the crests of slopes above active work sites. Safe access should be maintained at all times to the regions immediately above the active excavation. Frequent inspections may be necessary during periods of heavy rain or spring run-off and after large blasts.

The simplest method for monitoring tension cracks is to spray paint or flag the ends so that new cracks or propagation along existing cracks can be easily identified on subsequent inspections. Measurement of tension cracks may also be as simple as driving two stakes on either side of the crack and using a survey tape to measure the separations.

#### SCARPS

Scarps occur where material has moved down in a vertical or nearly vertical fashion. The material that has moved vertically and the face of the scarp may be unstable and should be monitored accordingly.

#### ABNORMAL WATER FLOWS

Sudden changes in rainfall or water flow may also precede slope failures. Spring run-off from snow melt or after periods of heavy rain is one of the most obvious examples of increased water flow which may have adverse effects on slopes. However, changes in steady flow from dewatering wells or unexplained changes in piezometer readings may also indicate subsurface movement that has cut through a perched water table or intersected a water bearing structure. Changes in water pressure resulting from the blockage of drain channels can also trigger slope failures.

Water can also penetrate fractures and accelerate weathering processes. Freeze-thaw cycles cause expansion of water filled joints and loosen slope material. Increased scaling may be necessary during cold weather.

#### CREEP OR SLOW SUBSURFACE MOVEMENT

Bulging material or ‘cattle tracks’ appearing on a slope indicate creep or slow subsurface movement of the slope. Other creep indicators can be determined by looking at vegetation in the area. While most quarries or mines do not have vegetation on slope faces, the movement of trees at the crest of a slope can indicate instability.

#### RUBBLE AT THE TOE

Fresh rubble at the toe of a slope or on the floor of the excavation is a very obvious indicator that instability has occurred. It must be determined which portion of the slope failed, and whether more material may fail. One of the most dangerous situations to occur is an overhang. If workers are not aware that a portion of the material below them has failed, they may unwittingly venture out onto an unsupported ledge. Remedial measures such as scaling, supporting, or blasting the overhang or other hazardous rock may be necessary.

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[49] Girard. J. M. (September 2012). Assessing and monitoring open pit mine highwalls. WA, Australia. Sourced from www.cdc.gov/niosh/mining

## 7.4 SLOPE MOVEMENT MONITORING PROGRAMS

Sufficient, suitable slope movement monitoring should be provided as required by a geotechnical assessment or risk assessment to detect instability at an early, non-critical stage to allow for the initiation of safety measures. Monitoring "after the fact" does little to undo the damage caused by unexpected failures.

Mining operations must, and quarry and alluvial mine operators should, address the collection, analysis and interpretation of relevant geotechnical data. This must include monitoring of openings and excavation and seismic activity in their ground or strata instability PHMP[50].

The purpose of a slope movement monitoring program is to:

> maintain safe operational practices for the protection of workers, equipment and facilities
> provide warning of instability so action can be taken to minimise the impact of slope movement
> provide crucial geotechnical information to analyse the slope failure mechanism and design the appropriate corrective measures.

Planning a slope movement monitoring program should involve the following steps:

> definition of site conditions
> prediction of all potential mechanisms that could control instability
> determination of parameters to be monitored and potential magnitude
> establishment of suitable monitoring systems, including instrumentation and location
> formulation of measurement procedures, including frequency, data collection, processing, interpretation and reporting
> assignment of tasks for design, construction and operation of systems
> planning of regular calibration and maintenance
> establishment of trigger action response plans (TARPs) and associated accountabilities for action to minimise impacts of slope movement.

Monitoring methods for slopes can be surface and subsurface and qualitative and quantitative. All have their place in specific environments and are often related to the potential failure size. The selection of the most appropriate technique depends on site-specific conditions.

Regardless of the technique used, if there is an adequate level of monitoring and a good understanding of the ground conditions, the onset of major slope failure can be detected in advance. The safety risks can then be managed to an acceptable standard.

### 7.4.1 MONITORING METHODS

The type of instruments selected for a slope monitoring program depends on the particular problems to be monitored. A comprehensive monitoring system may include instruments capable of measuring rock mass displacement, ground water parameters, and blast vibration levels.

When selecting monitoring instruments, incorporate some level of redundancy in the system to cross-check instrument performance and eliminate errors. Redundant or over-lapping measurements will also provide a back-up in the case of instrument failure.

Automated equipment is generally more accurate than manual equipment since some human error is removed. Automated systems also provide added flexibility in the sampling rate and can therefore monitor more

[50] The Regulations, regulations 71 (2) (e) and 71 (2) (f)

frequently than manual readings. Another distinct advantage of automated systems is their ability to trigger alarms if certain threshold limits are reached.

Instruments should be placed where they will be the most effective. Estimating the movement expected in a particular area should help ensure the limits of the instrument are not exceeded. There may also be environmental limitations (ie extreme heat or cold) that determine whether a particular instrument will work at a specific site. All of these factors need to be evaluated against the primary objectives of the monitoring program.

For more information on typical surface and subsurface monitoring methods see Appendix L: Monitoring Methods. Included is information on:

> visual inspection
> surface extensometers and crack monitoring
> terrestrial geodetic surveys
> GPS Stations
> radar
> subsurface techniques
> micro-seismic monitoring
> monitoring of groundwater pressure.

### 7.4.2 INSTRUMENTATION DATA

A detailed draft of monitoring and reporting procedures should be prepared during the planning phase and finalised after the instruments have been installed. At that time responsible workers will be familiar with operation of instruments and specific site considerations. These procedures should include:

> a list of data collection
> equipment specifications, including servicing requirements
> processing and presentation procedures
> interpretation procedures, including alarm levels.

COLLECTION OF INSTRUMENTATION DATA

A competent geotechnical engineer or instrumentation specialist, selected by the site, is responsible for collection of instrumentation data determined during the planning phase.

For more information on instrumentation data, see Appendix M: Instrument Data. Included is information on the following:

> processing and presentation of instrument data
> interpretation of instrumentation data
> responding to data variations
> reporting conclusions.

## 7.5 REMEDIAL MEASURES

The selection of remedial measures taken following slope movement depends on the nature of the instability and the operational impact. Each case should be evaluated individually with respect to safety, site plans and cost-benefit analyses.

Generally speaking, stabilisation and repair methods are used when ground movement has already occurred where artificial support methods are used to prevent instability.

**Let the material fail:** If the failure is in a non-critical area of the excavation, the easiest response may be to leave the material in place. Work can continue at a controlled rate if the velocity of the failure is low and predictable and the mechanism of the failure is well understood. However, if there is any question about the subsequent stability, you should make an effort to remove the material.

To prevent small-scale failures from reaching the floor of the excavation, both the number and width of benches can be increased. Catch fences can also be installed to contain falling material.

**Support the material:** If allowing the instability to fail is not an option, artificially supporting the failure may be a solution. Some operations have successfully used reinforcement such as bolts, cables, mesh, and shotcrete to support rock mass. The use of such supports can be very expensive. However if the overall angle of a batter can be steepened and clean-up costs are reduced, the added expense of reinforcement may be justified.

A careful study of the geological structures should be performed to select the proper reinforcement (ie length of bolts or cables, thickness of shotcrete and so on). Bolts that are too short will do little to prevent slope stability problems from continuing. In some cases, reinforcement has only served to tie several small failures together, creating a larger failure.

Another potential solution to stop or slow down ground movement is to build a buttress at the toe of the slope. The buttress offsets or counters the driving forces by increasing the resisting force. Short hauls of waste-rock often make this an attractive and economical alternative for stabilizing slope failures.

**Remove the hazard:** If a slope continues to fail, and supporting the slope is not a feasible alternative, you should remove the hazard. Flattening the slope to a more favourable angle with respect to the local geology will often solve the problem. When catchment systems are not available, appropriate scaling methods should be employed regularly to remove hazards associated with small rockfalls.

Removing (or unweighting) the top portion of a slide may decrease the driving forces and stabilize the area. However, this option is generally unsuccessful and in some situations involving high water pressure, unloading actually *decreased* the stability of the remaining material.

Since water pressure creates slope stability problems, dewatering using horizontal or vertical wells can be a significant way of controlling slope behaviour and minimizing hazards. Surface drainage and diversions should also be used to keep surface runoff away from tension cracks and open rock mass discontinuities near the slope face.

### 7.5.1 INSTALLATION OF ARTIFICIAL GROUND SUPPORT AND REINFORCEMENT

If artificial ground support and reinforcement are included in the slope design, it is essential they are installed correctly and the timing of their installation is an integral part of the design implementation. For more detailed information on ground support and reinforcement systems see section 3.6.

Although some of the work involved in the installation of artificial ground support and reinforcement can be carried out from a safe distance (ie shotcreting, drilling, and so on.) the installation of mesh and bolts, including the plating and tensioning of them, may expose workers to much greater rockfall hazards than usual.

The increased risks to safety during installation must be clearly recognised and managed. In addition, no worker should enter an area of the operation that has unsupported ground unless they are installing or supervising the installation of ground support. Where any worker installing or supervising the installation of ground support will be exposed to a hazard associated with unsupported ground, temporary support must be provided to protect them[51].

Managers must ensure suitable ground support methods are designed and implemented for all working areas and plans showing the ground support put in place are displayed in locations readily accessible to all workers[52].

Consider the following when installing artificial ground support and reinforcement:

**Storage and handling:**

> Artificial ground support and reinforcement products should be stored and handled to minimise damage or deterioration.

[51] The Regulations, regulation 118
[52] The Regulations, regulation 119

> Steel components designed to be encapsulated in resin or cement grout should be clean of oil, grease, fill, loose or flaking rust and any other materials which may damage the grout.

**Grout and other additives:**

> Grout is mixed according to the manufacturer's or supplier's instructions including cement to water ratio, correct mixing time and speed and water quality.

> Any additives (eg retarders, accelerators, fluidisers) to the grout mix should be added in the recommended amounts and at the specified time in the mixing and pumping process.

> Where full grout encapsulation of steel elements is required, the method of grouting should show a grout return at the collar of the hole. Other methods that can demonstrate complete hole filling may also be appropriate. All grout mixing and pumping equipment should be cleaned and maintained regularly.

**Procedures during installation:**

Procedures for artificial ground support and reinforcement installation should include:

> the method of work

> the support materials and equipment to be used

> the layout and dimensions of the artificial ground support and reinforcement system

> any method of temporary support necessary to secure safety

> the procedures for dealing with abnormal conditions

> the method and equipment for withdrawal of support

> manufacturer's instructions relevant to the safe use of support

> information on other hazards such as known zones of weakness, or proximity to other workings or boreholes

> the area to which the procedures apply and the date they became effective[53].

Correct tensioning procedures (when required) should be used for the various types of artificial ground support and reinforcement. The purpose of tensioning of cables should be determined to establish whether post-tensioning or pre-tensioning is required.

Also consider:

> Orientation of the hole should be appropriate for the geometry and expected mode of failure.

> Plates or straps against the rock surface should have adequate thickness to prevent nuts being pulled through the plate or strap when loaded against the rock surrounding the hole.

> Shotcrete thickness should be tested regularly during placement to make sure the specified thickness has been applied. A means of permanently marking the shotcrete surface with a depth gauge probe may be appropriate.

Samples of the shotcrete mix should be collected at specified intervals, under normal operating conditions. They should be tested in a suitably recognised concrete testing laboratory for compliance with the shotcrete design specifications. These should state the slump of the mix, the uniaxial compressive strength and a measure of the toughness of the product.

**Procedures following installation:**

> Have monitoring arrangements to ensure the artificial ground support or reinforcement system continues to be effective including monitoring for corrosion.

[53] Sourced from HSE: Approved Code of Practice and Guidelines – The control of ground movement in mines

## 7.6 HISTORIC UNDERGROUND WORKINGS

Sites may mine or extract materials that have previously been mined by underground methods. There are high-risk hazards that can arise where opencast mines or quarries approach and then progressively mine or extract through underground workings.

These hazards include:

> sudden and unexpected collapse of the ground or walls
> the loss of people or equipment into unfilled or partially filled underground workings
> loss of explosives from charged blast holes that have broken through into the underground workings
> overcharging of blast holes where explosives have filled cavities connected to the blast hole
> risk of ejecta (fly rock and so on) from cavities close to the floor and adjacent blast holes, particularly when explosives have entered the cavity from the blast hole during charging and the loss is not detected.

In general, the above hazards are significantly increased when the underground workings were not backfilled at the time of mining. As these hazards are not generally evident during normal operations you should take additional measures to better define their nature and extent.

### 7.6.1 HAZARD IDENTIFICATION OF UNDERGROUND WORKINGS

A thorough review of previous mine plans is essential before development.

The validity of old underground mine plans should be thoroughly checked, particularly if they are abstracted or copied from originals. Whilst this is important to assess the likelihood of abandoned underground workings around an open pit, its accuracy may not be relied upon.

A review of underground workings should be part of the design and planning of the site to make sure, as far as practicable:

> All known underground workings are marked clearly on all working plans and the plans rechecked.
> There is recognition that the rock mass surrounding the underground workings may be highly variable in strength and potentially unstable.
> A three-dimensional model of underground workings is developed and used in all design, planning and scheduling.

It is essential all plans are updated following all phases of exploration to ensure the revised outlines of the actual extent and shape of underground workings are recorded.

Where it is unlikely underground workings could be of large dimensions and extended in length and depth, or where no previous plans are available, it may be necessary to confirm the location of the underground workings.

A number of detection methods are available which may be used to confirm the lateral extent and shape of underground workings including:

> probe drilling
> geophysical techniques (including seismic, resistivity, conductivity and gravity methods)
> ground probing radar
> laser based electronic distance measurement (EDM) surveying methods
> closed-circuit television (CCTV) cameras lowered through probe holes
> where practicable, actual physical inspection and survey.

Once the relevant hazards have been adequately defined, you must put in place controls to mine or extract safely through the underground workings.

#### 7.6.2 RISK CONTROL

Consider the following control measures to eliminate or minimise the risk of unexpected floor or wall collapse:

> placing fill materials into the underground workings
> leaving a pillar of adequate dimension between the current working bench and the underground workings by stowing or collapsing
> restricting work to areas clear of the suspect location, with an adequate margin of safety
> blasting waste rock into voids, followed by further back filling to stabilise the area.

If there is a risk of intersecting underground workings, a geotechnical assessment should be carried out to determine the minimum stable floor pillar or rib pillar dimensions.

All areas of a working bench likely to be underlain by underground workings should be clearly marked and access to the area controlled by a specific set of procedures. These procedures should address a range of issues including:

> minimising pedestrian movement
> the workers responsible for monitoring and marking out the hazardous areas
> probe drilling procedures
> marking out the extent of the underground workings
> drilling and blasting
> plant and equipment movement
> placement of fill materials in unfilled workings
> rock stability monitoring
> daylight and night operations
> plant and equipment specifications
> regular communication of information and discussion of issues of concern with all those involved
> review of the procedures as the depth of the pit increases.

Allowance should be made for the uncertainty in the precise position of underground workings and any potentially unstable ground surrounding the underground workings. An extra margin of safety should be allowed in the separation of permissible works areas from suspect zones.

When extraction approaches operating underground mines, the potential hazards may include:

> flooding of the underground workings
> instability of the slopes and surrounding surface areas
> adverse effects on the underground mine ventilation system
> spontaneous combustion
> collapse of unfilled stope voids
> deficiencies in co-ordination, communication and control of mining activities between the surface and underground mines.

Each of these hazards must be adequately investigated and controlled by appropriate means according to the identified risk.

### 7.7 WORKING NEAR SLOPES

Managing hazards from individual rocks falling from a slope (highwall or face) is done through a combination of four techniques. These are:

> supporting or controlling the fall path of potentially loose rock
> scaling the loose rock
> providing rock catching berms or benches or both
> limiting workers' exposure to areas where loose rock is on the slope.

Before allowing people to work near a slope, the slope should be thoroughly inspected for hazards including loose rock. Where loose rock is identified it should be scaled off the slope or the area beneath the loose rock should be cordoned off. Benching effectively reduces workers' exposure as does moving roadways and work areas farther out from the base. In addition, mobile plant should be worked perpendicular to the base of the slope as it provides the operator with a better view of the face.

When working near slopes the following safety precautions should be followed:

> A bench is located in the slope above the work area. Space the bench so you can clean the face of the immediate wall (the section of wall from the floor up to the first bench) with mobile plant or equipment available at the site.

> The workers must not be positioned between the slope and any part of any mobile plant or equipment that would hinder their escape from falls or slides.

> Safe access to the top of the slope must be provided to allow for examinations of ground conditions.

> Clear the top of the slope of loose, hazardous material before the shot material exposing the face is brought down. Use mobile plant (eg an excavator) that can reach the edge of the wall from safe staging and use the outward force of the bucket to remove loose material from the top edge of the wall.

> A buffer must be provided that locates workers a safe distance out from the toe of the wall. This may be achieved by placing the loading excavator on a rock platform with a rock trap (or trench) between the excavator and the face (see Figure 36).

> Mobile plant should work perpendicular to the face or toe while in the impact zone.

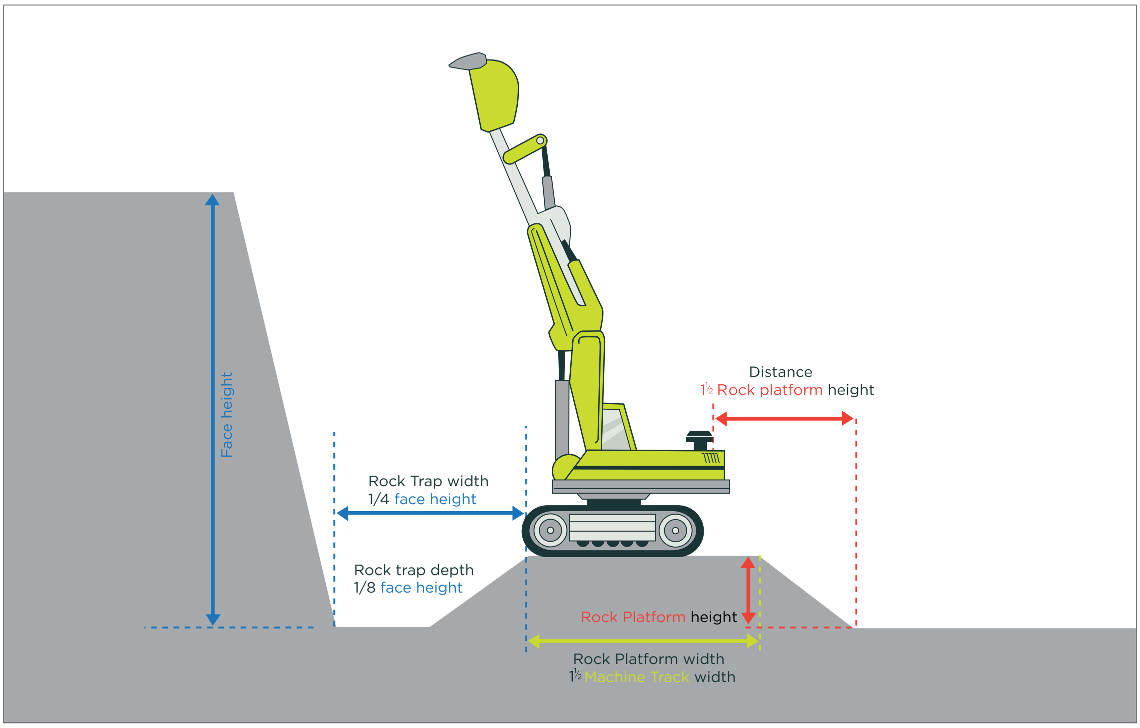



**Figure 36:** Rock trap design

PART C

# 08/

## TIPPING (OR DUMPING)

IN THIS SECTION:


8.1 Dumping methods
8.2 Controlling end-tipping risks
8.3 General risk controls
8.4 Procedures for examining tip heads
8.5 Tip maintenance and inspection
8.6 Other considerations for stockpiles
8.7 Reworking or reshaping tips

## Instability or movement in tips and stockpiles can cause serious harm. To minimise this risk, actively manage tips and stockpile, and have robust procedures in place.

This section describes:

> common risks from tips and tipping and ways to control them

> procedures for inspecting tip heads and tip condition.

Incidents can occur for various reasons when dumping. Mainly these reasons are unsafe tip head conditions, unsafe dumping practices, or some combination of the two.

Some unsafe dump point conditions include:

> **No windrow or restraint, or an inadequate windrow or restraint.** Makes the edge location difficult to judge; offers inadequate restraint to keep a vehicle from going over the edge.

> **A windrow that is too narrow** at the base. Allows the heavy loading of the truck to get so close to the edge of the tip that the edge material may not be strong enough to support the weight.

> **An edge of a tip that has been weakened** because the tip has been loaded out at the toe and over steepened. Edge material may not be able to support the truck weight, and its own weight. A portion of the windrow may have fallen away reducing the windrow's capability to provide restraint.

> **An edge of a tip that has been undercut.** Overhanging conditions can be created especially when the tip material is frozen, or has sat for an extended period of time.

> **Cracks, settlement, or a slide near the edge** of the tip. The edge may be unstable and may not support the additional truck weight.

> **A soft area near the edge** of the tip. May cause tyres to sink in and the truck to tip over as it attempts to dump.

> **A tip that runs downgrade to the windrow**. Gives drivers less control while backing, and can soften the dump area from poor drainage.

> **A tip that's placed on a soft or weak foundation.** As the tip gets larger, the slope may become unstable due to the foundation giving way underneath the tip.

> **Inadequate lighting** for night operations, or **poor visibility** during inclement weather. Makes driver judgements, and detection of unsafe conditions, more difficult.

> **Inadequate clearance** between equipment and overhead power lines. Two particular concerns are that truck trays are raised at dump points, and as tips get larger the clearance may be gradually reduced.

> **Congestion around the tip head** where dump trucks or other mobile machinery congregate and crowd the tip head due to operational delays or unplanned events.

### 8.1 DUMPING METHODS

There are three methods of dumping:

1. **Paddock dumping** where loads are dumped close to each other and, if another layer is to be built on top, the surface is levelled and prepared for the next lift using mobile plant.
2. **Dump short and push off** where loads are dumped and pushed off a tip edge.
3. **End-tipping** where loads are dumped down a free face and the load slides down requiring regular maintenance and re-building of windrows.

Paddock dumping or dumping short and pushing off are the preferred options for all tips. This is because these methods generally eliminate the hazard of trucks driving off an edge or the edge collapsing due to increased weight from trucks. Under carefully managed circumstances end-tipping can be done safely.

## 8.2 CONTROLLING END-TIPPING RISKS

Whenever heavy vehicles are operated near the edge of a slope, there is a risk the edge material will not support the vehicles. This is especially relevant on tips or stockpiles where the material is normally in a relatively loose condition.

In a tip or stockpile the material is typically at its 'angle of repose'. The angle of repose is the angle at which the material rests when simply dumped in a pile. This angle will vary depending on the size and shape of the constituent particles, how the material is dumped and the amount of moisture in the material when it is dumped.

For a pile of material at its angle of repose, the edge of the pile is by definition marginally stable. When dumped or pushed over the edge, the material tends to slide until it comes to rest at an angle where it can just barely support its own weight. This is why it is hazardous to bring the heavy weight of a truck close to the edge of an angle of repose slope. When this occurs, the slope material must support not only its own weight, but also the additional weight of the loaded truck. If the additional weight of the truck causes the material's shear strength to be exceeded, the edge of the slope will give way under the weight of the truck. This is the reason there is an ongoing history of serious incidents at uncontrolled tip heads.

The edge of a pile can also become unstable if the foundation cannot support the weight of the material and begins to give way. Especially in a tip of overburden, the edge may become unstable because of a zone of weak material in the tip. Sliding may occur on a layer of the material.

Because the tip head must be capable of supporting the weight of the vehicles being used, normally a truck, and withstand the other dynamic forces imposed in stopping and dumping near the edge, engineering processes and checks that tips are being maintained to meet design specifications and tolerances are essential. This is to make sure tip edges remain stable and capable of withstanding the weight of vehicles dumping over an edge.

End-tipping should therefore only be done where the following risk mitigation measures are in place and maintained:

> A geotechnical assessment[54] of every tip with a minimum Factor of Safety of 1.2 (refer section 4 for more information).

> Tips and tip heads (including windrows) should be designed (with drawings, see figure 37 for an example); formed from consolidated layers; and terraced or stepped back to minimise fall risks.

> The edge and windrows should be systematically maintained while end-tipping.

> The windrow should be used as a visual guide only. The windrow should not be used to help stop the truck but only as a visual guide to judge where to stop.

> There is adequate supervision of dumping operations to make sure unsafe conditions are being corrected and safe practices are being followed.

> There are specified intervals for reviewing the end-tipping and auditing of the processes.

> Unusual material (eg weaker or wetter) should always be treated differently than standard overburden. Unusual material should always be paddock dumped in an area where it will not compromise tip stability.

Track-dozers are preferred for maintaining tip heads because they distribute the weight

[54] The Regulations, regulation 81 (b)

of the mobile plant over a greater area than a rubber-tyred dozer, subsequently decreasing ground pressure. This practice should be encouraged.

When dumping short, a good rule of thumb is to dump one truck-length back from the edge. The benefit of using this method is that the truck drivers are not exposed to the potential hazards at the edge of the tip. They can complete the haul quicker since they don't need to be as precise in backing and positioning the truck when they are dumping.

To eliminate the hazard of trucks reversing into water, only backfill water filled areas by the dump short and push off method.

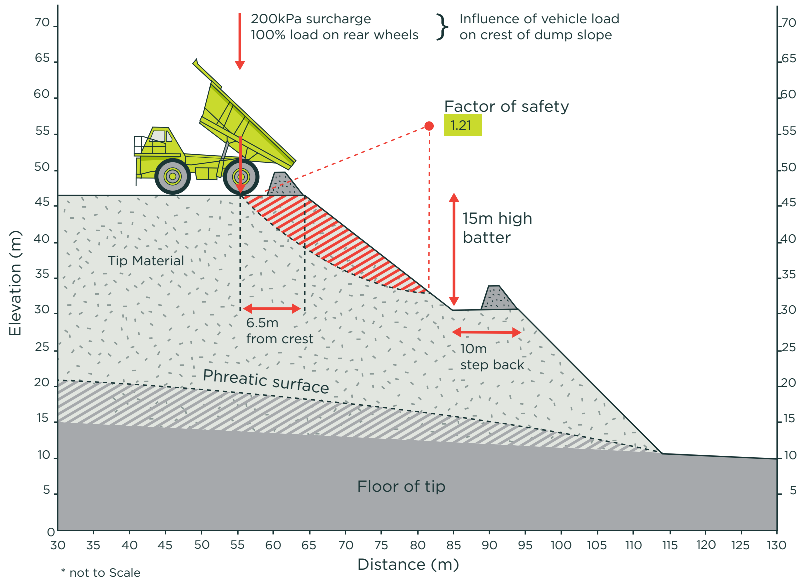



**Figure 37:** Example of tip slope stability design (limit equilibrium)

### 8.2.1 TIP CONSTRUCTION PROCEDURE

All tips should have a construction procedure to follow when dumping. This procedure should:

> Describe how the tip design, from the geotechnical assessment, will be implemented by the workers.

> Specify the overall slope angle, maximum heights of batter slopes and minimum bench widths.

> Consider the type of material being dumped and the dumping method.

> Consider the size and type of vehicles being used.

> Include windrow specifications (refer 8.2.3 for more information).

> Be easily understandable by the workers dumping.

Workers should be trained in the procedure and dumping should be monitored, to ensure the procedure is being followed.

Using diagrams is a good way to communicate the procedure to workers. Figures 38 and 39 are examples of easily understood tip construction procedures that describe how the tip design from the geotechnical assessment will be implemented.

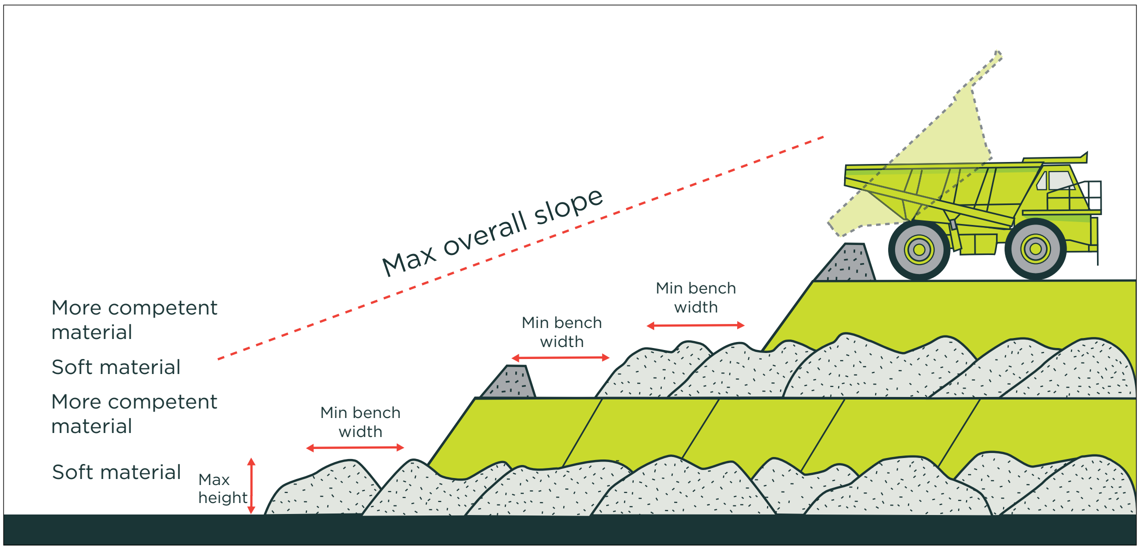



**Figure 38:** Example dump construction method for mixed material (mattressing)

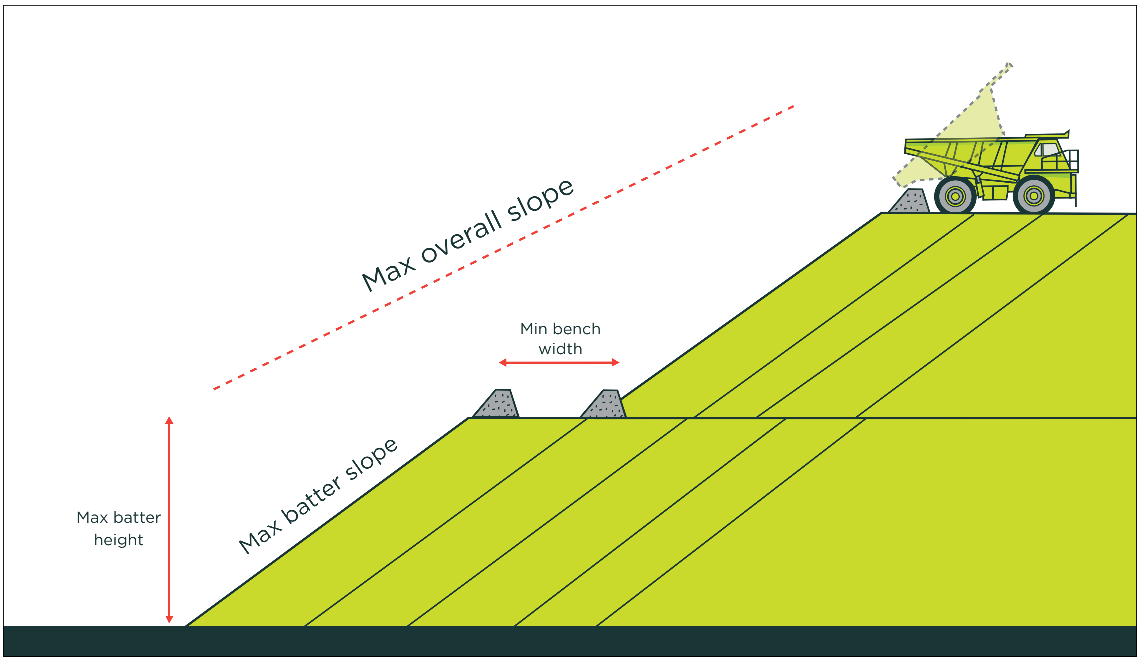



**Figure 39:** Example dump construction method for competent material

These are only two potential dump construction methods. The procedure that the mine follows should be based on the geotechnical assessment.

Using diagrams is a good way to communicate the procedure to workers.

### 8.2.2 DUMPING METHODOLOGY

Loads should be dumped in phases according to the design to ensure stability and to allow the tip face to be built out uniformly. A phase is a series of dumps whereby progressive loads are dumped adjacent to the previous one (refer Figure 40).

At the end of each phase the tip surface, edge and windrow should be reformed (taking into consideration any compaction or movement of the windrow that is required) before the next phase starts.

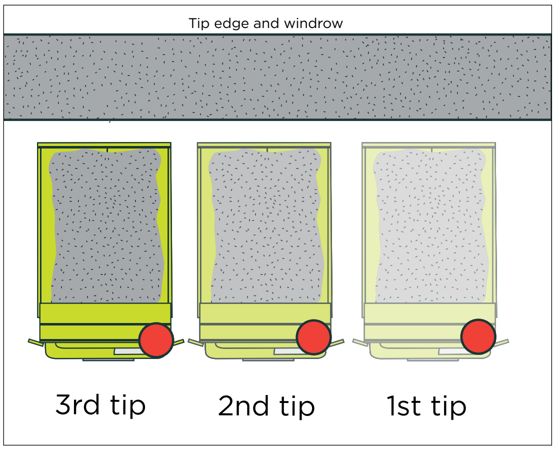



**Figure 40:** Dumping sequence

There should be communication between the mobile plant operators and the truck drivers to advise when the next phase can start.

When reversing close to the edge of a tip, drivers should reverse slowly and come to a gradual stop at the tip head. As a truck reverses up and the brakes are applied, dynamic forces are produced which push down and out on the tip. The more abruptly a vehicle stops, the higher these forces are. These forces can make a stable edge give way.

Drivers should reverse perpendicular to the edge, or with the driver's side tyres leading just slightly (refer Figure 41). In many tip head accidents, the tyre tracks have revealed the truck was reversing at an angle, with the rear tyres opposite the driver leading. In these cases, the driver's side mirror would have indicated the driver still had a distance to back up, while the opposite side rear tyres were already contacting the windrow or going over the edge.

The windrow or backstop should be used as a visual guide only. The windrow or backstop should not be used to help stop the truck. On no account should a vehicle be allowed to mount windrows or backstops.

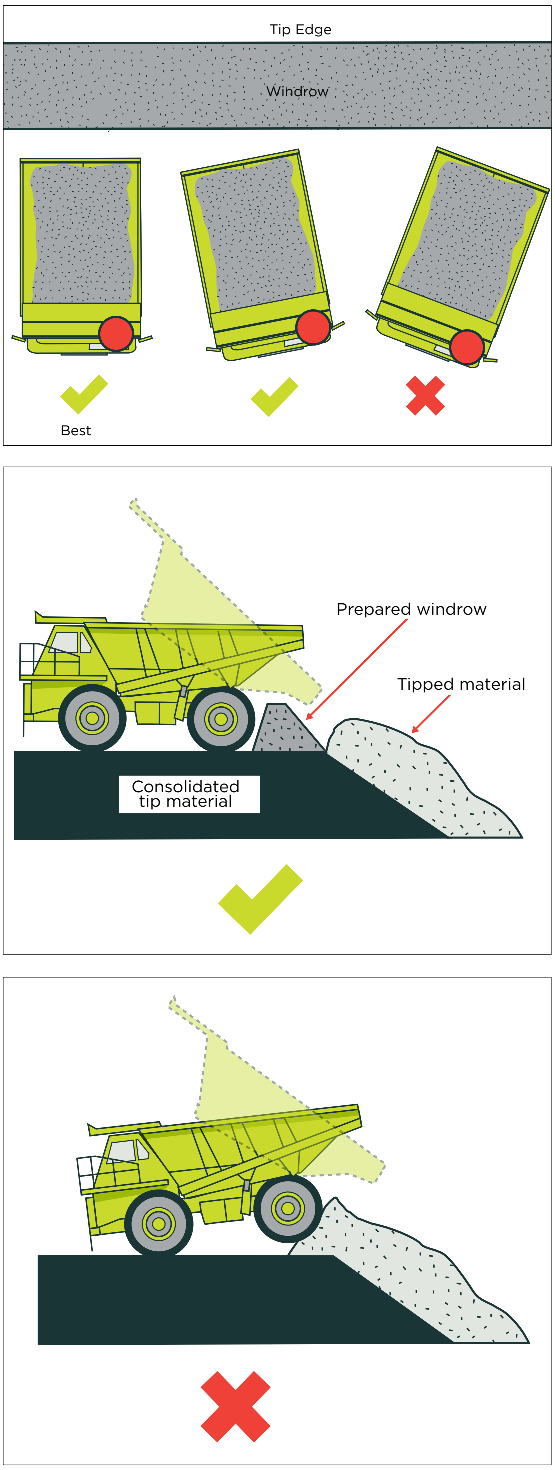



**Figure 41:** Approaching tip point windrow

#### 8.2.3 CONSTRUCTION OF WINDROWS AT TIP HEADS

A critical function of a windrow at a tip head is to keep the heavy load on the rear tyres of the truck from getting too close to the edge. In this respect the height of the windrow is important because the higher the windrow, the wider the base of the windrow. It is this wide base that is critical in keeping the load back from the edge.

Windrows should be seen as a safety extra and should not be used as a brake or even an indicator that the edge has been reached. They must be designed, constructed, installed and of sufficient height to offer definite restraint in the event a vehicle accidentally contacts them. While traditional rules of thumb for windrow heights (ie half the height of the wheel) may be useful, they are often not supported by design calculations and could be inadequate as a safety barrier.

Design parameters for windrow construction should be followed. Design parameters include:

> Using material to construct the windrows that is non-uniform in size, to allow interlocking of particles for greater cohesion and strength.

> Sloping the outer face of the windrow to its natural angle of repose. The slope should be pushed up steeper on the inner face (but must maintain adequate width).

> The width and distance must be enough to keep the heavy loading on the rear tyres of trucks from getting too close to the edge where the material could give way.

#### 8.2.4 CONSTRUCTION OF STOP-BLOCKS (OR WHEEL BACK-STOPS) AT PERMANENT TIP HEADS

When a truck (or loader) dumps off a permanent tip head (eg into a hopper) adequate stop-blocks should be in place. The stop-block should be designed, constructed, installed and of sufficient height to offer definite restraint. The stop-block should be adequate for the largest vehicles that will use the tip head. Remove spills (including gradual build up) that accumulate in front of the stop-block as these will reduce the height of the block.

### 8.3 GENERAL RISK CONTROLS

#### 8.3.1 OVERHEAD HAZARDS

Carry out dumping operations clear of overhead hazards such as power lines, pipework and so on. Continuously check for overhead hazards. If a tip or stockpile increases in size, vehicles may gradually begin working closer and closer to overhead hazards that were too far away to be a concern when the tip or stockpile was started.

#### 8.3.2 VISIBILITY OF A DUMP SITE

Adequate lighting must be provided. The area should be illuminated well enough to allow signs of tip head instability, such as cracks, to be detected. If visibility is poor (eg due to bad weather conditions), dumping should be stopped or other controls implemented to maintain safety (eg trucks should dump back from the edge).

During adverse weather a trigger point should be established that will determine when operations will need to be modified or stopped due to reduced operating parameters. This can include visibility, temperature (freezing), traction on pavements (rain) and wind.

### 8.3.3 VEHICLE MANOEUVRING

It will usually not be possible to completely avoid reversing of trucks where dumping has to happen. However, reduce the amount of reversing to as little as possible. For more information on reversing, refer section 10.1. Tip heads should be of sufficient size to permit manoeuvring by the largest equipment that is intended to be used.

### 8.3.4 DUMP-POINT SURFACES

The horizontal surface at the tip head should be kept level from side to side so trucks won't tip on their sides when the tray is raised (refer Figure 42).

The surface of the tip head should be kept sloped a small amount so, when reversing to the tip head, the trucks will be going up a slight grade (refer Figure 43). This gives the driver better control. It also provides a better opportunity to get the truck out if any shifting of the ground occurs, and keeps the tip head better drained.

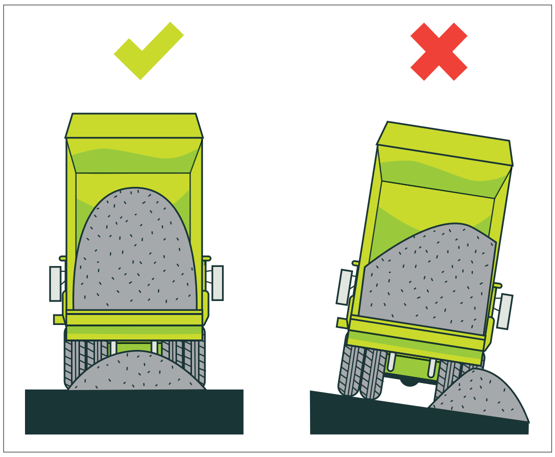


**Figure 42:** Vehicles should be parked on level ground (side to side) when dumping their load

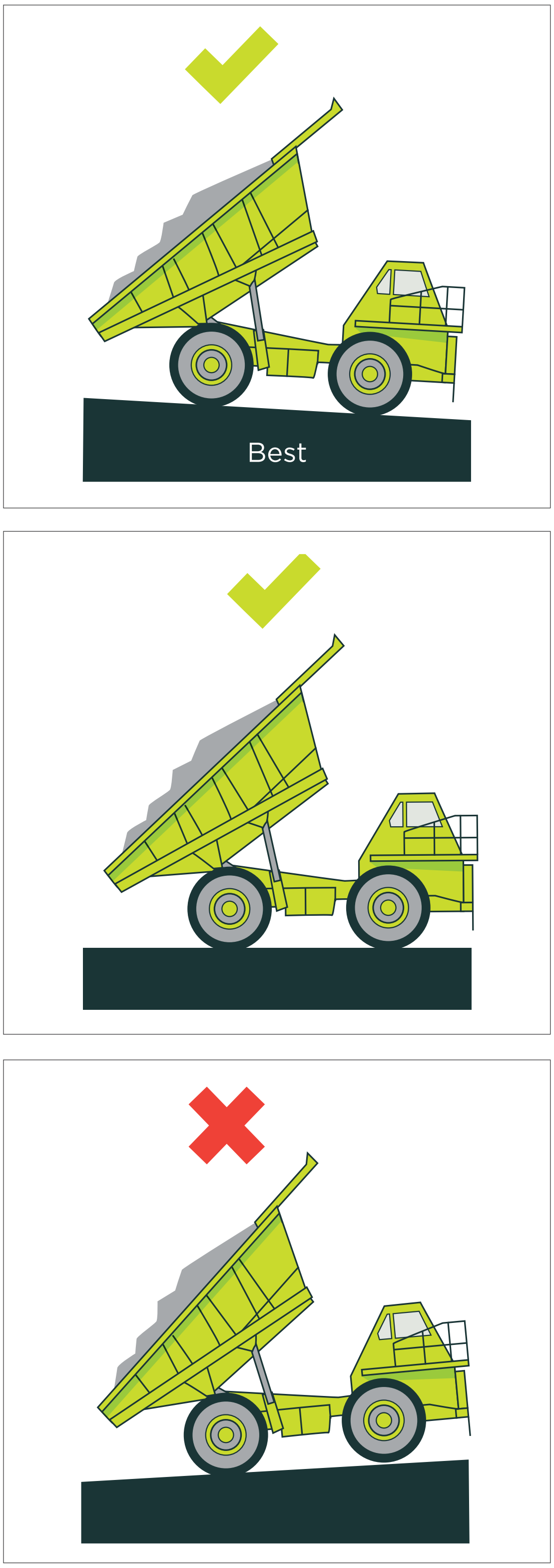



**Figure 43:** Dump on level ground with a slight uphill gradient

#### 8.3.5 COMMUNICATION

There should be a clear and effective system that allows communication between anyone entering the stockpile or dump area, such as two-way radio.

A protocol should be established to define who is coordinating the tip head. If a dozer is present at the tip head it is good practice to assign this to the dozer driver. If a dozer driver is not constantly present then other arrangements should be made where multiple trucks may be present at the same time.

#### 8.3.6 USING SPOTTERS

A spotter is someone who guides a truck into the dumping position, either from a safe viewing platform protected from the elements, or in a stationary vehicle.

A spotter should always 'spot' the truck from the driver's side. Where spotters are used radios should be provided.

Spotting platforms should be highly visible to all vehicles.

#### 8.3.7 USING TECHNOLOGY

Make use of new technologies such as proximity sensors and vehicle mounted cameras that can improve both tip head safety and efficiency.

A rearward facing camera can assist a truck driver in backing up square to the tip head and in knowing how close to the windrow the vehicle is positioned. They should be provided at all times where end-tipping is undertaken.

#### 8.3.8 TRAFFIC FLOW

Consider the types of vehicles entering the tip head when determining a direction of travel (eg driver cabs may be on the left or the right hand side). Approaching with the tip head to the driver's cab side gives the driver the best opportunity to check the condition of the tip head just prior to dumping.

Drivers should stay back from the edge a minimum of one truck length on their approach and in making their turn.

#### 8.3.9 TOE EXCLUSION ZONE (PROHIBITED ZONE)

A toe exclusion zone should be established at a safe distance from the toe of all working tip and stockpile slopes. Barricade fencing, windrows or traffic cones and warning signs should be erected where there is a risk of harm.

#### 8.3.10 RESTRICTED ACCESS FOR LIGHT VEHICLES AND WORKERS ON FOOT

To make sure no additional traffic hazards are introduced there should be restricted access to operational areas of a tip for light vehicles and workers on foot. Signs should be erected indicating restricted access areas.

Where light vehicles are required to access the tip head you should establish dedicated light vehicle parking areas and have protocols in place to eliminate pedestrian and heavy vehicle interaction, stopping operations until pedestrians have left the tip head.

#### 8.3.11 SEGREGATION OF VEHICLES AT THE TIP HEAD

Demarcated routes, for use during night or day, should be provided. This should ideally separate access to and exit from the dumping areas. One-way routes are preferable. By restricting movement to defined routes grading and watering requirements are reduced.

Vehicles in the dumping area should remain in the view of the driver of a reversing vehicle at all times; that is, on the cab side. Vehicles should remain at least one truck width apart from other vehicles while dumping (refer Figure 44). This leaves room in case a truck tips over on its side while attempting to dump. Truck drivers should never drive within the reversing path of another vehicle.

Do not reverse a vehicle blindly in a dumping area. Drivers should make full use of visibility aids and should not reverse until they are certain the path is clear and only if protection is in place adjacent to any edge of a hazard. Safe operating procedures should outline the protocols and rules when working at a tip head.

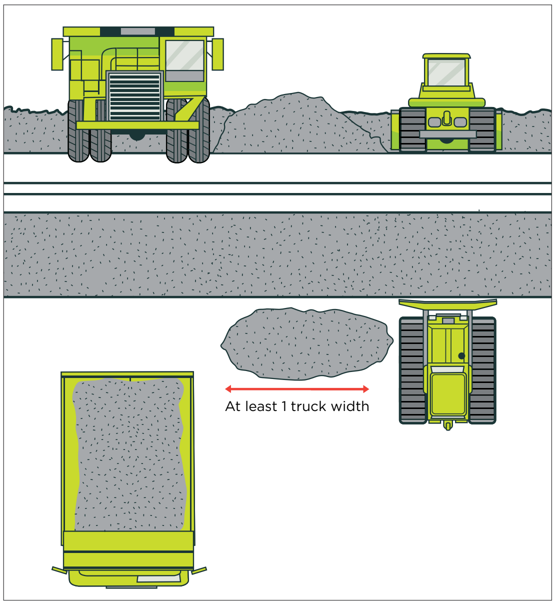



**Figure 44:** Vehicle separation at tip point

Light vehicles should go to the designated area if there is one. If not, they should stay a nominated distance away from the trucks dumping or queued to dump, similar to having a loading clearance zone. Trucks should queue in a location that ensures they will be safely separated from the dumping truck and in clear view of that truck's operator.

#### 8.3.12 DUMPING THE LOAD

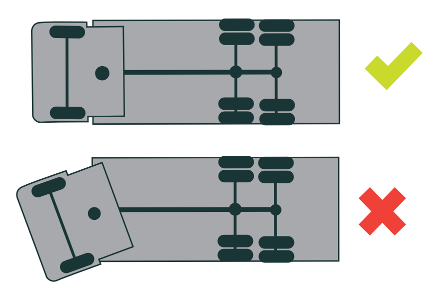
Drivers should be trained on how to safely handle sticking material (hang-ups). Sticking material can make the truck tip over as the tray is raised or cause a more critical loading condition on the edge of the tip. If the tray gets to about two-thirds of the way up and material is still sticking, the driver should lower the tray and find another means of getting the material out (ie using a backhoe). When material sticks in the tray, on no account should drivers try to jar it loose by jamming on the brakes as they reverse. The truck could tip over, the tray hoist could fall causing sudden extreme movement, or if this is done near the edge of a tip, the added force could cause the edge to collapse.

A safe system of work should be established for dumping loads. When the truck is positioned the driver should apply the park brake before putting the transmission into neutral. When the hoist or tray is rising, the truck driver should use the mirrors to watch the material flowing from the tray to ensure there are no side spills or uneven flow (which may indicate a hang-up). Check for cracking or slumping of the tip head.

#### 8.3.13 RAISED TRAYS AND ALIGNMENT OF ARTICULATED VEHICLES

The vehicle should stay level if it is moved forward during dumping. Driving with the tray raised should be restricted to short distances, and only where it is required to fully discharge a load. Raised tray alarms and built in speed controls can reduce the risk of vehicles being driven with the tray raised.

Always align the tractive unit and trailer of an articulated vehicle when dumping (refer Figure 45). Provide enough space for a vehicle to manoeuvre the trailer and cab so they are lined up.



Articulated vehicles should be parked straight when tipping

**Figure 45:** Articulated vehicles

### 8.3.14 REMOVING MATERIAL FROM A STOCKPILE

The removal of material from the toe of a stockpile can have a significant effect on the stability of the edge. In the case of loose, free-flowing material, loading out at the toe may have little impact because the material tends to slide back to its angle of repose. Once material has become tightly packed from vehicles on the stockpile, or from sitting for a period of time and settling in, the area where material is loaded out will generally stand at a steeper angle. Material standing at about 35 degrees when dumped over the edge can typically stand at 45 degrees once loaded out. In some cases, such as when material has been sitting for a long time, the material may stand even steeper or may even stand in an overhanging condition. With these steepened conditions, there is less slope material to support loadings on the stockpile, and a sudden failure could occur.

Mobile plant operators should be trained to continuously trim the face so it does not overhang and collapse (refer Figure 46). Faces should be worked in a straight line so that wings do not develop and create a crescent face which can be self-supporting in the short term.

Barriers should be installed to restrict access to the top of the tip above the area which is being loaded out. The purpose of the barriers is to isolate the potentially dangerous edge (which could be undercut) from drivers and to eliminate material being dumped on to the loader.

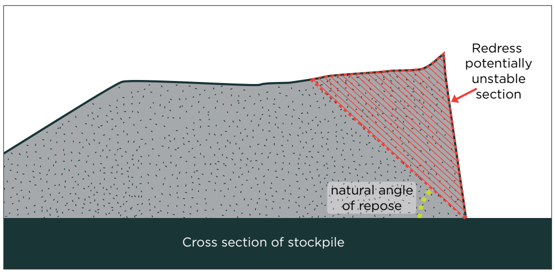



**Figure 46:** Cross section of stockpile

## 8.4 PROCEDURES FOR EXAMINING TIP HEADS

It is critically important to examine a tip head for unsafe conditions on a regular and on-going basis. Tip head conditions can change due to new material being dumped, the effects of equipment near the tip head, weather conditions, or even just the settling-in of material with the passage of time. In stockpiles, a big factor affecting the tip head condition is the loading-out of material from the toe of the pile.

At a minimum, tip heads should be visually inspected by a competent person prior to work commencing, at least once during each working shift, and more often if necessary for safety. A written record should be made of each inspection.

Operators and supervisors should be trained in unsafe conditions and practices at tip heads. Operators and supervisors should routinely check the area for unsafe conditions, such as cracks, inadequate windrows, unstable material on the slope below the tip head, or a loaded-out slope below the tip head. Such conditions should be immediately reported and acted on including the suspension of operations as required.

For more detailed information on what to look for at a tip head see section 8.5.

At a minimum, before and during each work shift the tip surface, edges and faces should be inspected by a competent person for any evidence of instability. Refer Regulation 222 of the regulations for specific examinations required.

**Regulation 83 Inspection of tips**

If the PHMP for tips, ponds, and voids required regular inspections to be carried out, it also must specify:

(a) the nature and interval of inspections; and

(b) the appointment of a competent person to supervise the conduct of tipping operations, including a requirement that this person supervise every inspections of a tip at the mining operation.

**Regulation 122 Defects discovered during inspection of tips**

(1) The mine operator must ensure that any person who carries out an inspection of a tip at the mining operation-
  (a) makes a written record of all defects discovered during the inspection; and
  (b) informs the mine manager of the defects that require immediate rectification.

(2) The mine operator must ensure that a written record is made of the action taken to remedy any defect in a tip discovered during an inspection of the tip.

(3) The mine operator must ensure that the records required by subclauses (1) (a) and (2) are kept as part of the health and safety management system.

## 8.5 TIP MAINTENANCE AND INSPECTION

Regular maintenance of tip surfaces should be undertaken, as well as the access and exit routes. This helps to make sure vehicle hazards due to spillage, wheel ruts, potholes and water ponding are minimised. Windrows or backstops should be maintained in height and profile.

Control dust generation using water trucks or spray systems to reduce dust nuisance and poor visibility hazards. Dust control in dumping areas should be at least equal to that in loading areas.

When completing inspections look for indications of inherent failure mechanisms or defects due to poor operational practices. These can include:

### 8.5.1 TENSION CRACKS OR SETTLEMENT

A tension crack or settled area near the edge of a tip or stockpile is a warning sign of an unstable, or marginally stable, slope. Cracking is an indicator that some movement has already taken place. If movement has occurred, then the slope material is unable to support its own weight, and it should not be relied on to support additional weight, such as a truck.

If there is a tension crack in the dump area, vehicles should not travel over or near the crack. The additional weight of the vehicles may trigger the slope to fail. Loads should be dumped a minimum of one truck-length away from the crack or in an alternative area.

Cracked areas should be clearly marked and isolated so the area is not used, or the condition should be immediately corrected by flattening that area of the tip. This can be done by dumping material at the bottom as a buttress, and carefully pushing material down from the top using a track-dozer.

Tension cracks will tend to run parallel to the edge of the slope. In some materials, other types of surface cracking may occur as a result of the material drying out. Drying cracks tend to be randomly oriented.

### 8.5.2 MOVEMENT OF SLOPE MATERIAL

A crack or a scarp (a steepened area where the material has slid) on the slope is an indication of instability. Bulging of the slope material is not always as apparent as cracks, but it is another sign the slope material is moving.

Bulging can be detected by looking along the slope of the tip, especially the area near the toe, and paying particular attention to any material that is not at the normal angle of repose. Bulging of the ground next to the tip is an indication the foundation underneath the tip is too weak to support the weight of the tip. A failure through the foundation could cause a portion of the tip to slide.

Where any signs or movement of bulging material is recognised, dumping operations should be immediately stopped. Dumping operations may resume after a risk assessment and consequent hazard controls (including reforming the tip) have been completed and actioned.

### 8.5.3 SOFT AREAS

Ruts and accumulations of water may indicate soft areas. The hazard in this situation is that as a truck starts to dump, the tyres may sink into the soft area. In the worst case this could result in the truck tipping over, especially if combined with material hanging up in the tray.

Soft areas should either be clearly marked so the area is not used, or the condition should be immediately corrected by re-grading and sloping the area to promote better drainage.

Drivers should stop dumping and move to a firmer area if they feel the tyres sinking into the ground and immediately report such occurrences to their supervisor.

### 8.5.4 INADEQUATE WINDROWS

Inspections should include checking windrows are adequate to prevent vehicles getting too close to the edge. Windrows must be designed, constructed, installed and of sufficient height to offer definite restraint in the event a vehicle accidentally contacts them.

It is important vehicles do not back forcibly into a windrow. As the tyres sink into the windrow, the heavy loading on the rear tyres gets closer to the edge, which can cause the edge to give way. Inspections should include checking for tyre marks on the windrow material. If you notice tyre marks, the potential hazard of this practice should be discussed with drivers immediately and appropriate action taken.

For more information on construction of windrows, refer section 8.2.2.

### 8.5.5 UNDERMINED SLOPES

When material is loaded out from the toe of a slope, it makes the slope less stable and more prone to sliding. In this weakened condition the material at the edge of the slope may not be able to support its own weight and the additional weight of a truck. An undermined slope is especially hazardous at a tip head because the additional weight of the truck, if positioned too close to the edge, can cause the edge to suddenly give way.

Because of this hazard, even without cracks or other signs of instability, dumping at or near the edge, where the tip has been loaded-out and undermined, should be strictly prohibited. If your examination identifies an undermined area, it should be cordoned off and rectified.

**Regulation 222 Examination of mining operations**

(1) The mine operator must ensure that a competent person –

- (a) Examines –
  - (i) Before the start of each working shift and at suitable times during each working shift, every area of the mining operation where a mine worker is or will be present; and
  - (ii) At least weekly, every accessible area of the mining operation, including every area containing barriers, machinery, seals, underground or surface infrastructure, and ventilation stoppings; and
  - (iii) At least weekly, every vehicle in the mining operations; and

(iv) Before it is started, any fixed or mobile plant in the mining operation that has been stopped for the preceding 24 hours or longer, and

(b) Takes all practicable steps to eliminate, isolate or minimise any significant hazard identified during the examination; and

(c) Ensures that all plant examined either is safe or is made safe.

(2) The mine operator must ensure that a written procedure for the conduct of examinations required by subclause (1) is included in the health and safety management system for the mining operation and sets out –

(a) The matters to be covered by the examination; and

(b) A timetable (subject to the minimum requirements of subclause (1)) for carrying out the examinations; and

(c) The process for recording findings; and

(d) The process for taking action as a result of findings.

## 8.6 OTHER CONSIDERATIONS FOR STOCKPILES

Walls or other supports provided to contain stockpiles should be designed by a competent engineer to ensure their stability.

If stockpiles grow to an extent that was not anticipated, they should be subject to a design review to ensure safety.

In windy conditions, spray water on the stockpiles to minimise the dust hazard (refer section 11.10).

### 8.6.1 ENGULFMENT

Engulfment can occur where loaders (or other mobile equipment) are removing material from a stockpile that is substantially higher than the loading equipment. Hazard controls (ie benching, height restrictions, and continuously collapsing the face so it does not overhang) and emergency procedures (in the case of an engulfment) must be established.

Where using draw down points (ie reclaims) there is a risk mobile plant will fall or inadvertently drive into a draw down hole. Major contributing factors include:

- The suitability of mobile plant for the stockpile design and operating environment (eg mobile plant operating alongside relatively steep stockpiles with heights above the safe limits of mobile plant).
- The operator not being aware of the location of draw down points and either driving into the hole, or sliding into the hole.
- The operator driving over the top of a bridged hole that suddenly collapses.
- Insufficient surface structures or other navigational aids that could be used by the operator to identify the location of draw down points.

Where there is a risk of engulfment, mobile plant should be designed to protect the operator and provide for prompt recovery of the operator. Consideration must be given to the rescue of people in the event of an emergency. Recovery systems and methods should be developed and tested. The controls outlined in Table 6 could be used.

| CONTROLS | COMMENT |
|---|---|
| The stockpile mobile plant should be designed to withstand engulfment forces of at least 40psi (280kpa) | Assumes a safety factor of 2:1 and is based on USA stockpile dozer incidents and investigations |
| Devices to assist the mobile plant operator in determining whether draw points are operating | Devices include:<br>> Flags<br>> Lights |
| Pedestrians should be prohibited from the hazardous area at all times | For example, draw down points |
| Provide communication devices so mobile plant operators can communicate with the control room in the event of an emergency | Devices include:<br>> Radio telephones (RTs)<br>> Cell phones (where reception allows) |
| Safety equipment to:<br>> Ensure the operator is in a safe atmospheric environment if the mobile plant cab is engulfed; and<br>> Facilitate rescue | Devices include:<br>> Breathing apparatus<br>> Rescue harness<br>> Emergency lighting<br>> Mats or portable bridges (to bridge the gap between stable ground and the engulfed mobile plant) |
| Position indicating devices to assist mobile plant operators in determining the location of draw down points in high risk zones should be used. Audible or visual alarms should be provided to alert the mobile plant operator | Devices include:<br>> GPS<br>> Cameras over draw down points<br>> Proximity detection<br>> Fixed structures to provide a reference point |

**Table 6:** Engulfment hazard controls at draw down points

## 8.7 REWORKING OR RESHAPING TIPS

Tips may be reworked or reshaped for landscaping or for operational requirements (eg forming roads over dumped material). A geotechnical specialist should be consulted when planning rehabilitation to ensure the stability of the tip at all times. For more information on rehabilitating tips, see section 4.6.

PART C

# 09/

## WATER-BASED MINING

IN THIS SECTION:

9.1 Planning and design
9.2 Excavation rules
9.3 Extracting beneath water
9.4 Floating plant and boats

This section describes how to:

> excavate safely under water
> safely access floating plant.

## 9.1 PLANNING AND DESIGN

Before any excavation, an appraisal of the ground conditions should be undertaken by a competent person to determine all factors likely to affect the stability of the ground and the limitations that should be imposed on the excavation design.

This should be documented. The assessment should be reviewed and revised where necessary when a material change has occurred in the ground conditions or the excavation methods. Effective ground control relies on geotechnical information obtained at different stages of the life of the site – during planning and design, at implementation of the design and through day-to-day operations.

Following appraisal of ground conditions, a design should be prepared setting out the measures to control ground instability. Where an existing design has already been proved, it may be used as the basis for the design of a new excavation, where the ground conditions at both sites are not significantly different.

During planning and design, there is usually a relative lack of data available when the design is first developed. It is essential that information obtained during operations is consolidated with information in the geotechnical model and continually used to assess the suitability of the design in relation to ground stability.

## 9.2 EXCAVATION RULES

Excavation rules should be drawn up setting out:

> the manner in which excavation activities should be carried out, specifying the type and reach of excavators
> the physical dimensions of the excavation including slope, depth, height of free faces, width of benches, position of catch-berms
> the way in which material should be removed from the excavation
> the nature and frequency of supervision
> response to defects.

## 9.3 EXTRACTING BENEATH WATER

Excavations should be kept stable even if you cannot see them. When extracting beneath water, slopes will be saturated.

Draglines, clam shells and long reach hydraulic excavators may over steepen the slope on which they stand and cause failure. These slopes should be treated as a significant hazard. Working methods should be based on the geotechnical assessment of the material being excavated allowing for any variation of submerged materials.

The working bench should be kept flat and clear of equipment or material to enable a rapid exit in the event of instability of the face. The front edge of the bench should remain visible to the operator at all times. Tracks should face the excavation, or be no more than a 45° angle, with track motors facing away from the face (see Figure 47, Figure 48 and Figure 49).

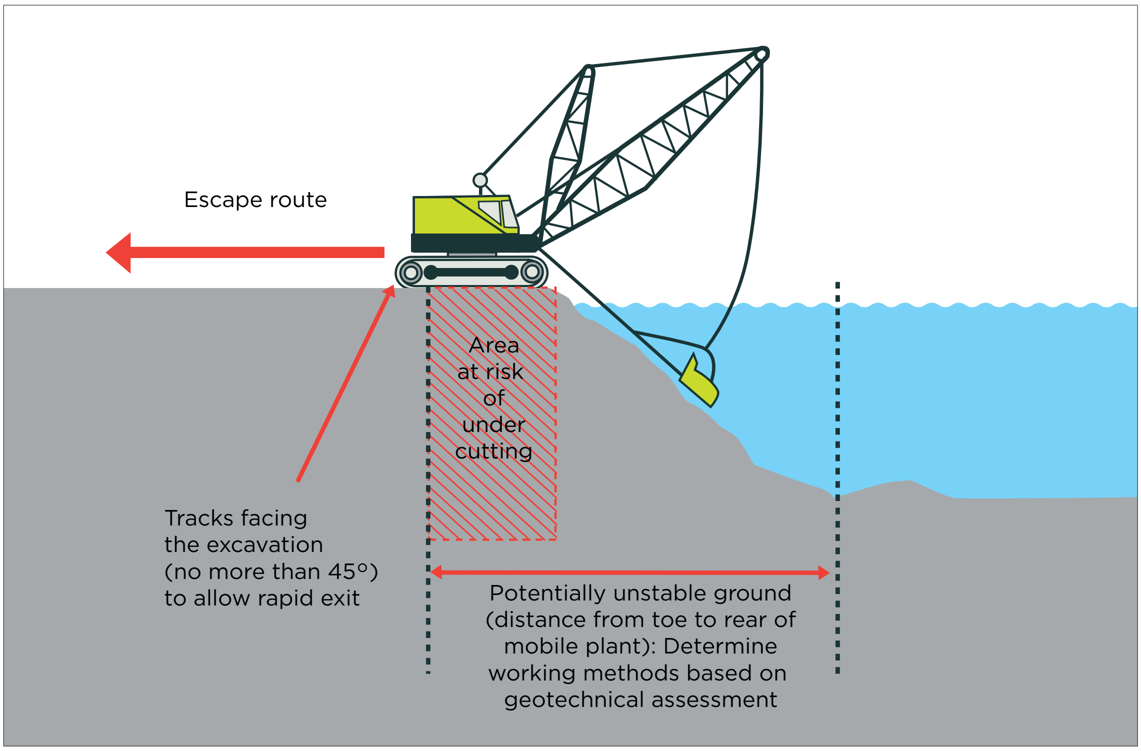



**Figure 47:** Dragline working beneath water

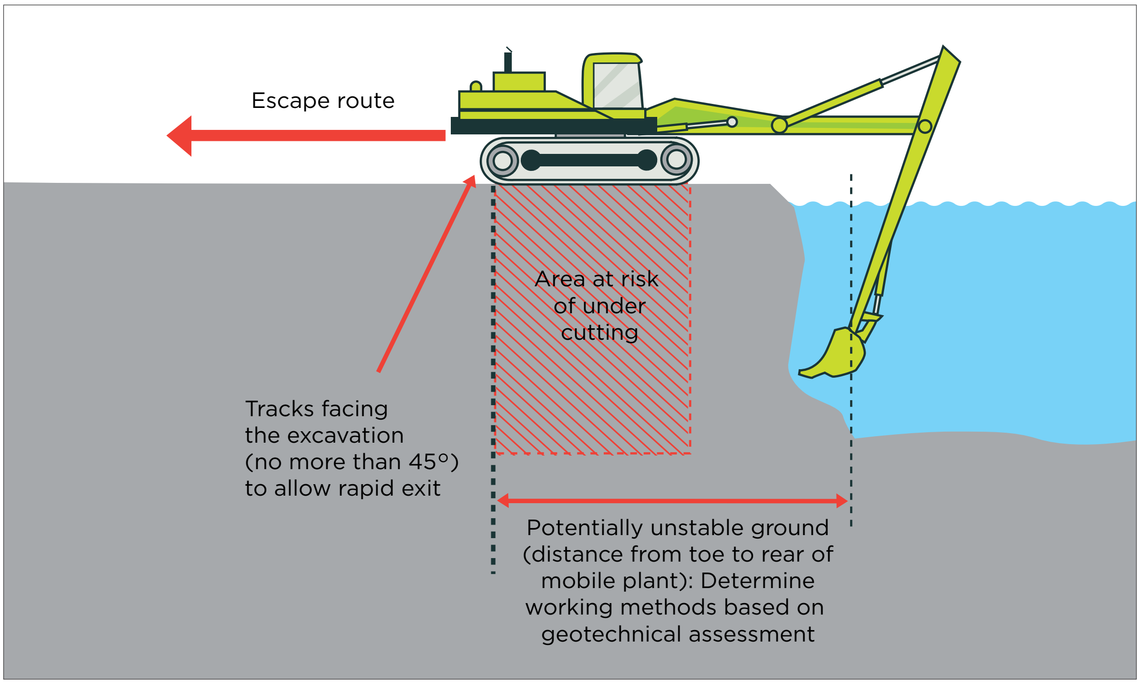



**Figure 48:** Long reach excavator working beneath water

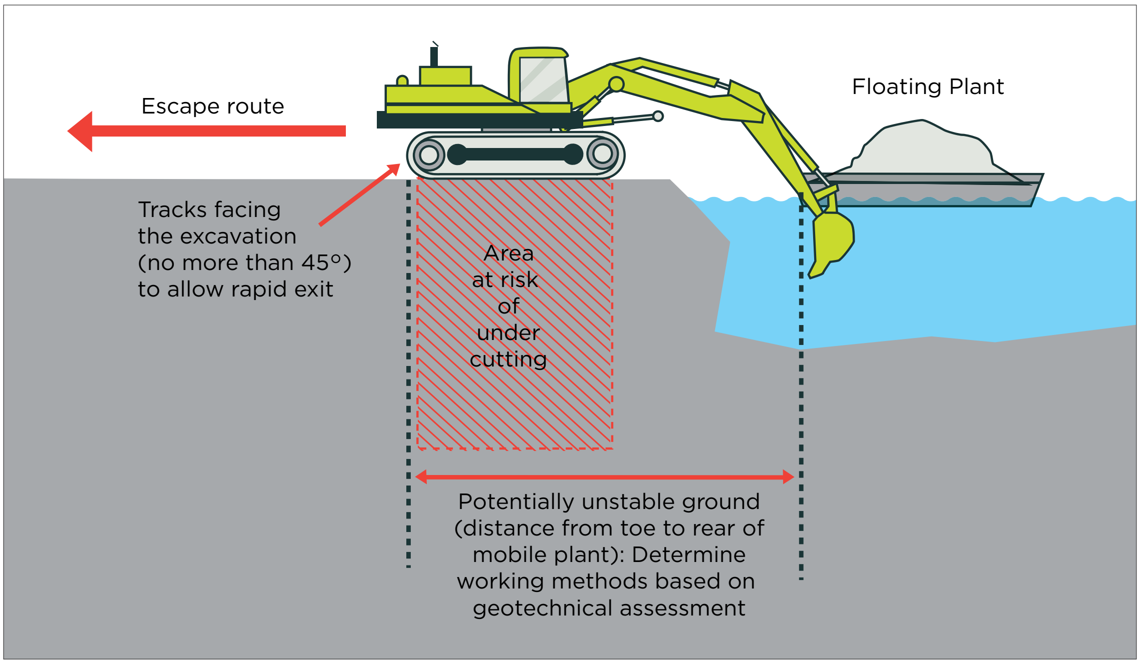



**Figure 49:** Excavator working beneath water, loading floating plant

Edge protection, barriers, warning signs and other suitable controls should be placed around any water filled excavation to keep people away from any hazardous zones. Edge protection, barriers or signs should be moved as the excavation progresses and the hazardous area changes. Rescue facilities must be provided (refer section 17).

If there is any doubt about the safety of excavations, operations must be stopped and remedial controls undertaken.

Where loading floating plant there should be clear signals or communication between the excavator operator and the floating plant operator so feeding can stop if required. Where trommel screens are used, a visual or audible warning device should be used to alert the excavator operator if the trommel has stalled. Such an occurrence can cause the screen to become overloaded and could compromise the stability of the floating plant if loading continues.

Emergency procedures must be in place. This may include equipping mobile plant with features or tools for use in an emergency; for example, push-out windows or window breaking tools.

## 9.4 FLOATING PLANT AND BOATS

Floating plant or boats (including those used on settling ponds) may be governed by the requirements set out in the New Zealand *Maritime Transport Act 1994* and *Maritime Rules* made under it. Nothing in this section precludes you from complying with the requirements of the *Maritime Transport Act 1994* or *Maritime Rules* where it applies to your vessel.

As a general guide the following documents will be needed for you to legally operate your floating plant or boat (hereafter referred to as vessel):

| VESSEL TYPE | SAFETY SYSTEM | MARITIME RULES RELATING TO DESIGN, CONSTRUCTION AND EQUIPMENT |
|---|---|---|
| Floating structures that are not navigable, that is they are permanently attached to the shore (eg floating jetties, gangways) | No maritime documentation | Not covered by the *Maritime Transport Act* or *Maritime Rules*. Covered by the *Building Act* |
| Barges over 24 metres in length | Barge Safety Certificate | Part 40C<br>Part 41 may apply<br>Part 42A<br>Part 42B<br>Part 43<br>Part 46 Section 3<br>Part 47 Section 3<br>Part 49 (where there are lifting appliances) |
| Barges less than 24 metres in length | Maritime Operator Safety System (MOSS) | Part 40C<br>Part 41 may apply<br>Part 42A<br>Part 42B<br>Part 43<br>Part 47 Section 2<br>Part 49 (where there are lifting appliances) |
| Barges less than 24 metres in length that do not:<br>> Have a lifting device with a WLL of 1 or more tonnes or<br>> Carry passengers (does not include crew)<br>> Carry cargo | No maritime documentation | |
| All powered vessels | Maritime Operator Safety System (MOSS) | Part 40C<br>Part 41 may apply<br>Part 42A<br>Part 42B<br>Part 43<br>Part 45 (partially apply)<br>Part 47<br>Part 49 (where there are lifting appliances) |

**Table 7:** Maritime rules

For more detailed information on the *Maritime Transport Act 1994*, *Maritime Rules* and maritime safety systems contact Maritime New Zealand or visit www.maritime.govt.nz.

Ensure floating plant will:

> not become unstable due to shifting loads or being overloaded

> remain stable while being towed

> remain water worthy in operating conditions.

Floating plant is to be designed, manufactured and maintained to the required standard.

### 9.4.1 SAFE MEANS OF ACCESS AND EGRESS

Safe means of access (eg gangway) should be provided to vessels, floating processing platforms, draw off points or submersible pumps where people have to access them for work purposes (refer Figure 50).

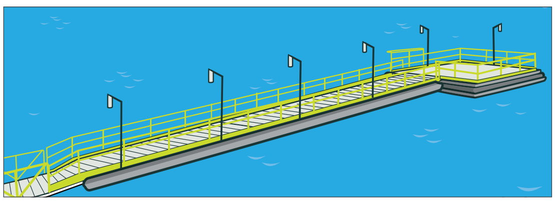


**Figure 50:** Example of gangway

Where using jetties, gangways, platforms, bridges or walkways they must be fitted with suitable handrails or other means to stop people falling in the water (refer Figure 51).

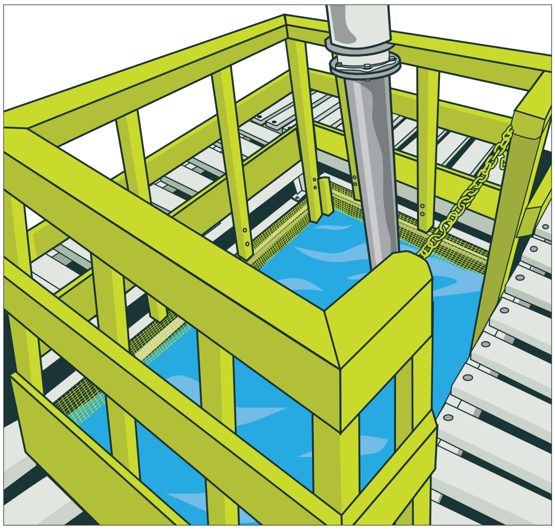


**Figure 51:** Example of guardrails around a water pick-up station

Cables and pipes should be separated or stored away from walkways to avoid tripping (eg in cable trays). Surfaces of walkways should be slip resistant.

Where traversing of jetties, gangways, platforms, bridges, walkways, stairs or ladders is required in the hours of darkness sufficient lighting must be provided.

Where ponds and floating processing plants are being used in alluvial mining, precautions should be taken at the edge of the excavation (refer section 7.5). Whilst emphasis should be given to the stability of large excavators and unstable ground conditions, this should also include pedestrians accessing floating platforms from the excavation edge.

In alluvial mining the use of excavator buckets to transfer persons over a short distance to a floating processing platform should only be permitted where:

> Pedestrians enter the bucket from a position well clear of the excavation edge.

> No tracking of the excavator takes place during the transfer.

> No articulation of the arm or bucket takes place during the transfer.

> The excavator bucket is fitted with grab rails positioned clear of any hinge points.

> The person in the bucket is wearing a self-inflating life preserver.

> A clear line of sight is maintained between the passenger and the excavator driver.

> The excavator boom hydraulics are fitted with hose burst protection valves.

Do not have personnel on board floating plant while it is fed by an excavator.

Consider providing remotely operated rope winch systems and power wash systems during the design stage ('safety by design'). This eliminates hazards associated with workers making frequent visits to floating processing platforms.

**Figure 52:** Digger and floating screen

For more detailed information on construction and installation of platforms, walkways, stairways and ladders see the Department of Building and Housing *Compliance Document for New Zealand Building Code Clause D1 Access Routes*.

### 9.4.2 DESIGN AND MODIFICATIONS TO VESSELS

Do not submerge dredge or floating plant decks under any circumstances. If the freeboard of a dredge or floating plant appears to be insufficient, a competent person should be engaged to evaluate and rectify the buoyancy. Dredge or floating plant operators should make sure dredge or floating plant decks do not become submerged under any operating conditions. This is particularly important when sludge builds up on the cutter head and when the cutter is driven into the bottom of the pond or into a working face during mining operations.

Equipment installed on the dredge or floating plant should be secure so that it won't shift and destabilise the dredge or floating plant.

Where trommel screens are used an automatic tripping device or warning should be installed to stop the trommel screen if the tailings discharge belt stalls. Such an occurrence can cause the screen to get overloaded if the operator is not alerted, and the whole plant can tip over.

Modifications can cause vessels to capsize due to additional weight or the effects modifications have on the balance of the vessel. Establish procedures to ensure modifications to the original design do not exceed the design capacity set by the manufacturer.

Procedures should also consider examination and maintenance of safety controls provided by the manufacturer to make sure modifications to the original design do not reduce the in process weight safety margin. For example, ensure dredge overload and full hopper alarm switches are functioning within the specifications of the manufacturer to maintain freeboard levels.

For more detailed information on barge stability see Maritime New Zealand *Barge Stability Guidelines*.

### 9.4.3 REPAIRS AND MAINTENANCE TO VESSELS

To ensure the integrity of vessels, you should establish maintenance and repair programs. These may include:

> Regularly checking decks and hulls for cracks and holes
> Sealing all covers over hatches in the deck with continuous excess marine sealant to ensure water tightness
> Regularly checking all hull compartment bulkheads are watertight, to isolate water flow should water ingress occur in any individual compartment
> Providing a sounding tube for each hull compartment that extends to near the bottom of the compartment so the compartments can be sounded daily for water ingress. Dredges should also have an adequate capacity pump with a non-collapsible suction pipe long enough to reach the bottom of any hull compartment. When water ingress is detected the water can be quickly and efficiently removed from the hull before buoyancy of the dredge is seriously affected.
> Procedures to make sure repairs are undertaken in pontoon cells when leaks develop.
> Regularly checking ropes and rigging for signs of wear.

The use of polyurethane or polystyrene in hull compartments does not ensure buoyancy of dredges. It is recommended these materials are not used because the materials deteriorate over time, becoming porous and water absorptive, and they do not allow for regular inspection of the hull compartment surfaces.

Hull compartments are confined spaces and a confined space working procedure is to be used.

Refer to AS 2865 for more information on confined space entry.

For more information on Repairs and Maintenance see section 16.

### 9.4.4 BOATS

Boats, like any other equipment, should be of adequate size and power to properly perform the anticipated task. Remember, weight capacity includes people, motor, equipment and any other haul load. Consider the weight of a retrieved item if a retrieval operation is undertaken.

Boats must be operated by workers who have adequate experience or training or who are supervised by a competent person.

You must have a Maritime Operator Safety System (MOSS) for all powered vessels. For more detailed information on MOSS contact Maritime New Zealand or visit their website at www.maritimenz.govt.nz.

### 9.4.5 PERSONAL FLOTATION DEVICES (PFDs)

Establish and enforce policies for wearing Personal Flotation Devices (PFDs). Like seat belts on vehicles, PFDs are effective only when they are worn.

Provide sufficient quality PFDs of the proper type appropriate for each worker's weight. Maintain the PFDs in serviceable condition and replace them if they become worn or damaged.

Generally, Type 401 open waters lifejackets are the most appropriate lifejackets for a working environment. Type 401 lifejackets are designed to keep an unconscious person face up in the water. PFDs may include life buoys and life lines (ropes) stationed at suitable locations.

When using lifejackets they must meet *NZS 5823:1999, NZS 5823:2001, or NZS 5823:2005 – Specification for buoyancy aids and marine safety harnesses and lines* – or another national standard substantially complying with the New Zealand standards. These include US, Australian, European and ISO standards.

Take into account the PPE and equipment a worker will have on their person when considering PFDs. Lifejackets are to keep a worker's face out of the water, in case they are rendered unconscious.

### 9.4.6 ROPES, PULLEYS, WINCHES AND RIGGING

All floating plant will require mooring. This is often accomplished using winches and ropes.

On smaller plants with manual winches and rope, the main hazard is that of tripping. Larger plants may have substantial winches and large diameter wire ropes. These present additional hazards from gear failure (ropes or pulleys breaking) and whiplash as strain is exerted on rigging. Exclusion zones should be defined.

Ropes, pulleys and other rigging should be covered or otherwise protected. Workers should stand well clear of any hazardous zones when the ropes are taking strain. For more detailed information on load lines see Part 47 of the *Maritime Rules*.

Anchoring should be firmly positioned and not prone to undermining.

The use of galvanised ropes is advisable to prevent the unseen, internal corrosion that can occur in steel wire ropes operating constantly in and around water. Regardless of the rope used, all associated equipment such as pulleys, rope clamps and sheaves should be specified based on the rope diameter and safe working load.

### 9.4.7 EMERGENCY EXITS

Cabins should have an emergency exit in the event of a sinking or capsize, such as a push-out window or a trap-door.

PART C

# 10/

## WATER OR TAILINGS STORAGE

**IN THIS SECTION:**


10.1 Inspections and tell-tale signs of distress

10.2 Technical operational review

10.3 Cleaning out ponds

## Instability or failure of ponds and tailing dams can cause harm. Design, construct, operate and maintain ponds and tailing dams appropriately to prevent this harm.

This section describes how to:

> inspect ponds and dams, and identify potential causes of failure
> review ponds and dams periodically
> maintain ponds and dams.

SSEs must take all practicable steps to eliminate, isolate or minimise any significant hazard associated with ponds and dams. Safe systems of work should identify and control any risks to workers and anyone else who may be affected by activities associated with ponds and dams (including adjacent landowners). This includes workers who need access to potentially hazardous areas for purposes such as carrying out inspections and cleaning out ponds or dams.

Mine operators must make sure a competent[54] person examines ponds or dams where workers are, or will be, before the start of each working shift and at suitable times during the shift. At least weekly, every accessible area of the tip or pond, including areas with barriers, must be inspected by a competent person. Quarry and alluvial mine operators should undertake the same inspections where a tip or pond has been appraised as a principal hazard.

For more detailed information on principal hazard plans, planning and design criteria, geotechnical assessments and construction of ponds and dams see section 4.

### 10.1 INSPECTIONS AND TELL-TALE SIGNS OF DISTRESS

Once a dam has been constructed, regular monitoring (including routine visual inspections) and maintenance should be carried out to minimise the risk of the dam failing and to ensure it maintains compliance with the *Building Code*.

The most common failure mechanisms for a typical small earth dam are surface erosion from overtopping, internal erosion (ie piping or seepage) and embankment slumping. These failures can arise from defects such as spillway inadequacy, uncontrolled seepage, design and construction deficiencies, and a lack of maintenance.

If any of the following signs of distress or other unusual characteristics develop, immediate action should be taken to ensure safety and a technical expert contacted to investigate the dam to make sure it is safe and compliant with the *Building Code*.

#### 10.1.1 UPSTREAM SLOPE

The upstream slope of an earth dam or pond should be examined for any sign of erosion, beaching or slumping. These may be caused by wave action, flooding, or a rapid drop in the water level.

A damaged upstream face reduces the stability of the dam by limiting its ability to resist wave action and high water levels.

[54] The Regulations, regulation 222

Failure of the upstream slope can result from undercutting, erosion, depressions, and other evidence of the initiation of a possible slip or landslide.

### 10.1.2 CREST

The crest of a dam should be examined for shape and cracks. A variation in levels across the top of the dam may indicate abnormal settlement (vertical downward movement) or possibly an underlying void. Undetected, this may lead to the eventual failure of the dam as a result of the progressive development of internal erosion.

### 10.1.3 DEWATERING OR OVERFLOW CHANNELS

Dewatering channels should be checked for weed growth and side collapses. Safety issues include edge collapse while inspecting, silt build-up in the channel, and vegetation disguising undermined edges.

Overflows can be decanting pipes, angled pipes, spillways and armoured channels. These should be inspected regularly, particularly when there are periods of high rainfall. Inspections should include checking for blocked intakes of decant, or angled pipes with vegetation or other debris. A significant hazard when clearing blocked intakes is the sudden release of water into the pipe which can suck a person onto the intake causing injury or drowning. Blockages should only be cleared with machinery or tools that keep a person away from the intake.

Partially blocked overflow channels should be cleared quickly and safely. Remedial measures to limit the amount of floating vegetation in ponds should be established. Make sure armoured channels are not scoured when there is a high water flow. This can erode the dam crest and affect the integrity of the embankment.

### 10.1.4 DOWNSTREAM SLOPE

Ideally, an inspection for seepage should be made when the water is at or near its highest level. Examine the downstream slope, downstream toe, abutments, areas near spillways, and around and adjacent to outlets.

Seepage areas can be identified by wet spots or muddy areas, usually accompanied by the lush growth of tussock and other grasses. The use of piezometers will greatly increase the ability to detect seepage at early stages and should be considered as a control. You will normally need technical advice for the type and placement of each piezometer.

Small amounts of steady seepage (not concentrated flows) do not represent a serious condition, as long as controlled drainage is provided and ponding is not allowed to occur. An area of known seepage that suddenly stops or significantly decreases may indicate an area of distress and should be investigated.

## 10.2 TECHNICAL OPERATIONAL REVIEW

Periodic technical reviews should be undertaken by a competent person to assure the tip or pond is operating in accordance with the design intent. This can also ensure that regulatory requirements are being met (including those required by the *Building Act 2004*). Inspections and audits form part of this review using input parameters derived from site measurements, observations and testing.

Technical reviews:

> check that previous review recommendations have been actioned

> confirm appropriate responses have been made to any incidents or issues arising

> verify compliance with specifications (eg inspection, monitoring, quality control)

> verify compliance with legislative requirements

> validate the continued use of the tip or pond design
> recommend any necessary operational or design modifications.

The type and level of information provided in the review should be in-line with the tip and pond risk appraisal.

A record of review outcomes should be maintained. This should indicate any recommended actions and details of how they were addressed or implemented.

If the tip or pond is a dam under the *Building Act 2004* and requires a dam safety assurance programme (DSAP) under the dam safety scheme, the DSAP will also include requirements for inspection and review of the dam[55].

## 10.3 CLEANING OUT PONDS

The main risks when cleaning out ponds are created by undercutting and making the embankment unstable (particularly below water) or by mobile plant driving on to soft ground that cannot support the plant's weight.

Settling ponds can be deceptive, as they can form a crust which appears stable but the silt remains soft beneath. Access onto the silt should not be permitted unless capped and stabilised. Mobile plant should be kept back from the edge by at least a distance of 1.5 times the height of the face (refer Figure 53).

A risk assessment should be carried out to identify the appropriate methodology and plant to undertake silt extraction. The most common method is silt removal by an excavator. Alternative methods include dredges, suction pumps or vacuum pumps.

When using mobile plant, plant operators should constantly monitor the crest of the pond for signs of slumping, cracking or instability. If any signs of instability are observed, all work should stop; workers and plant removed, and access prohibited. Seek geotechnical advice if required.

The mobile plant operator should only remove silt as planned, and not excavate the pond retaining structure. The edge of the silt pond should be clearly demarcated at all times, ideally by barriers such as a bund. The mobile plant should be as far from the lagoon edge as operationally possible, and should be capable of obtaining the necessary depth of dig while maintaining the required stand-off. The mobile plant's tracks should be perpendicular to the pond edge so a safe, rapid exit from the area can be made if slope instability develops. The excavated silt should be cast as far away from the crest of the pond as possible to prevent loading of the crest which could cause failure. Silt placement should not block the safe exit route of the mobile plant. When not in use, all mobile plant should be parked at a safe location away from the water's edge.

[55] *Building (Dam Safety) Regulations 2008*, regulation 8

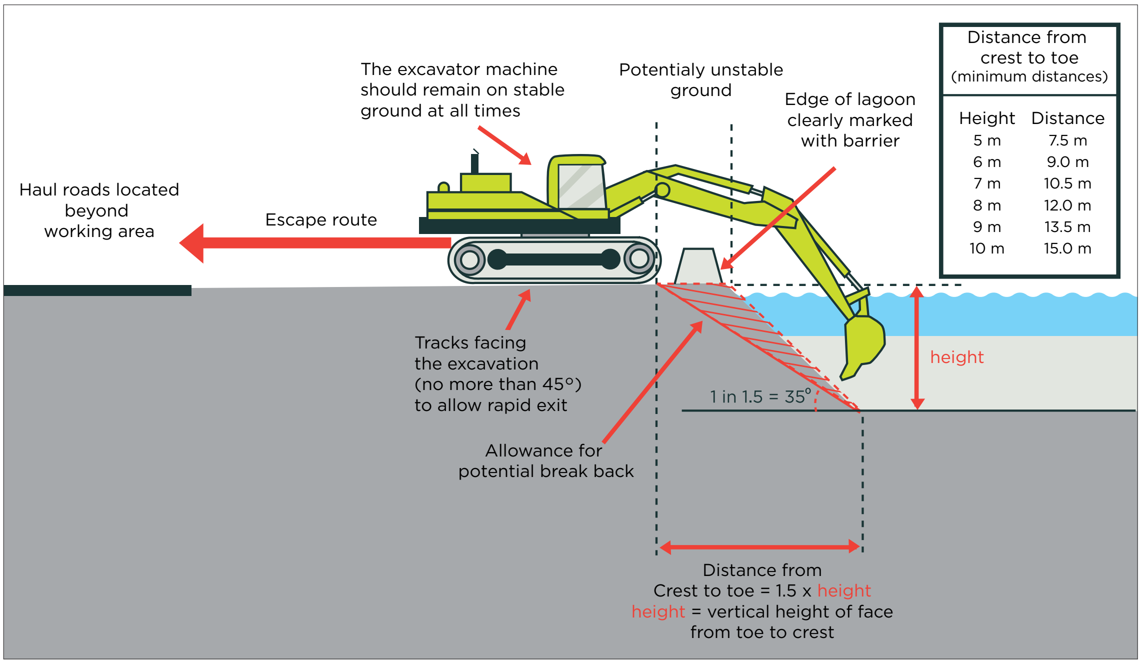



**Figure 53:** Example of cleaning out a settling pond with an excavator

PART C

# 11/

## TRAFFIC MANAGEMENT

### IN THIS SECTION:


11.1 Site access: contractors, visitors and public

11.2 Power lines and other overhead structures

11.3 Reversing, manoeuvring and parking

11.4 Loading vehicles

11.5 Loading floating plant

11.6 Loading and storage of large stone slabs or blocks

11.7 Feeding crushers

11.8 Railway sidings

11.9 Safe drivers and vehicles

11.10 Maintenance and repair of roads

## Any vehicle movement can pose significant risks at extractive sites, because of the size of the vehicles used and the environment people are working in.

This section describes traffic management measures for:

> moving around hazards
> keeping safe speeds, distances and manoeuvres
> using safe and appropriately-trained drivers
> selecting and maintaining suitable vehicles.

There are a number of ways vehicle activities can present a risk to workers at an extractives site. These include:

> the failure of a roadway (ie a collapse or slip)
> interactions between vehicles and pedestrians, vehicles and structures, or vehicles and vehicles (ie vehicles carrying passengers, light and heavy vehicle interactions)
> the loss of vehicle control (ie the driver falling asleep, mechanical failure or tip over)
> the extent of hazards on the roadway (ie sharp corners, steep inclines, drop-offs or traffic volume)
> other hazards involving vehicles (ie fire, explosion or visitor vehicles).

Give adequate consideration to the following in the design, layout, operation, construction and maintenance of every road within the mining operation:

> the grade and width
> the drainage system
> the characteristics of light and heavy vehicles to be used
> movement of light and heavy vehicles when forming tips or stockpiles
> the interaction between light and heavy vehicles[56].

This is good practice for all quarry and alluvial mine operators, and a legal requirement for other mine operators as defined in section 19M of the HSE Act.

## 11.1 SITE ACCESS: CONTRACTORS, VISITORS AND PUBLIC

On entering the site, vehicles and pedestrians should be directed to a safe area, depending on the nature of their visit. This is usually achieved by signage but may include road marking, footpaths or barriers. Allow sufficient parking spaces for workers and visitors.

Where site vehicles cross a footpath or turn from or onto a public road, consider public safety. This may involve discussions with the local council or New Zealand Transport Agency (NZTA) as part of the planning process.

### 11.1.1 CONTRACTORS AND VISITING DRIVERS

Carefully consider contractors and visiting drivers who are required to access operational areas. Assess their needs and where applicable, induct them to ensure they are aware of the site rules and procedures and what is expected of them.

For example, light vehicles (such as maintenance vans) are invariably required to attend breakdowns in operational areas. Give the visiting driver the traffic management plan, or escort them so their movements and operations are strictly controlled.

[56] The Regulations, regulation 120

Regardless of the size of the site you must establish safe systems of work which could include vehicle visibility standards (refer 11.9.4), induction systems and signage as required.

#### 11.1.2 PEDESTRIAN SEPARATION

Pedestrian activity in operational areas should, wherever practicable, be restricted particularly in the hours of darkness. Workers should not enter operational areas as a pedestrian unless authorised to do so.

Pedestrians must use separate routes wherever practicable, for example pedestrian only areas and safe, designated pedestrian routes (refer Figure 54). Other controls may include using light vehicles to transport workers to their place of work or, only allowing pedestrians to enter areas when vehicles are stationary (ie lunch breaks). Where separation by time is used as a control, check pedestrians have moved out of the area before operations recommence.

For smaller sites, or where only a few people are working, holding areas may be appropriate (eg signage stating visitors are to remain at the site hut until authorised to proceed).

Install a sign to inform people of prohibited zones (refer Figure 55).

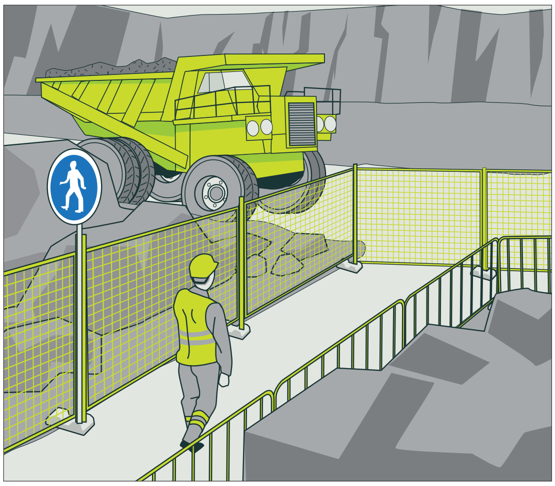


**Figure 54:** Example of pedestrian route


**Figure 55:** Example of signage for small sites

### 11.2 POWER LINES AND OTHER OVERHEAD STRUCTURES

#### 11.2.1 OVERHEAD POWER LINES

Overhead power lines on a site are likely to pose a significant risk, unless vehicles cannot approach them. Vehicles do not need to strike the overhead lines for injury to occur – electricity can arc a significant distance depending on the voltage and conditions.

The most effective way to prevent contact with overhead lines is by not carrying out work where there is a risk of contact with, or close approach to, the wires. Roads should be routed to avoid them. If there is a risk, and the road or working area is permanent (or long-term), consult its owner to find out if the line can be permanently diverted away from the work area or replaced with underground cables. If this is not practicable the following guidance applies.

Use precautions such as those illustrated in Figure 56 if it is possible for a vehicle to reach the danger zone around the cables. In risk assessment take into account the possibility of vehicles travelling with a raised tray.

No vehicle or its load can approach or work within at least four metres of an overhead power line unless written consent is given by the line's owner. For more detailed information on approach distances see the *New Zealand Electrical Code of Practice for Electrical Safe Distances (NZECP 34)*.

Where vehicles are likely to be used at any time in the proximity of overhead power lines, a permanent sign must be installed in a conspicuous place as near as practicable to the driver's position. The sign should be maintained in a legible condition and must state "Warning: Keep clear of power lines". For mobile crushers or transportable conveyors the sign should be installed in a conspicuous place at each towing point and adjacent to driving controls.

If work needs to be carried out below power lines and it is possible that vehicles could reach into the danger zone, the lines should be isolated and earthed before work begins. If this is not practicable, physical safeguards such as chains on the booms of excavator may be required to prevent vehicles reaching into the danger area.

Emergency procedures should outline what to do in the event of contact with an overhead power line (refer Section 18). Include the operator not exiting the plant and the vehicle being isolated, to manage the potential risk of electrocution or tyre explosion in the procedures. Most power line owners have information available on their websites for working around overhead and underground power lines. One example is available from Vector at vector.co.nz/safety/near-our-network.

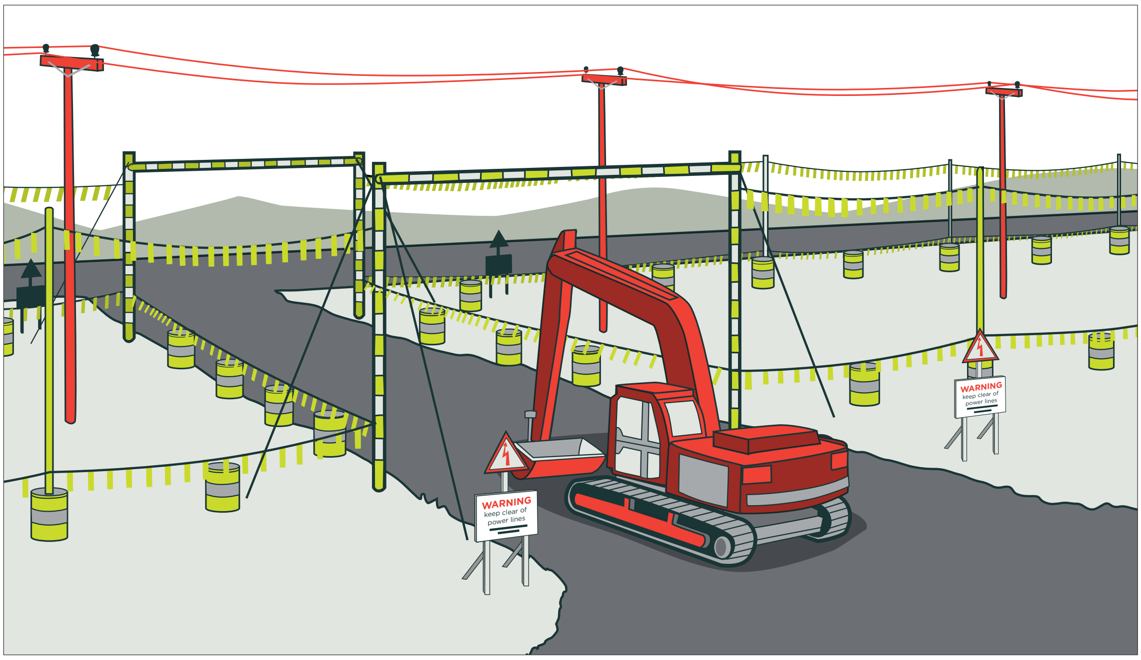



**Figure 56:** Safe working under overhead power lines

### 11.2.2 OTHER OVERHEAD STRUCTURES

Measure and record the vertical clearance under overhead obstructions on routes. The measurement should take account of any underhanging lighting, ventilation or other service features, which are often added after the initial design. Routes used by vehicles should allow for sufficient overhead clearance depending on the nature of the hazard.

Vehicle routes should also avoid anything that might catch on or dislodge a load.

Protect any overhead obstructions (such as electric cables, pipes, conveyors, walkways and so on) using goalposts, height gauge posts or barriers.

Give clear warnings of any limited width or headroom in advance and at the obstruction itself such as signs or audio warnings. For more information about signs refer section 5.3.16.

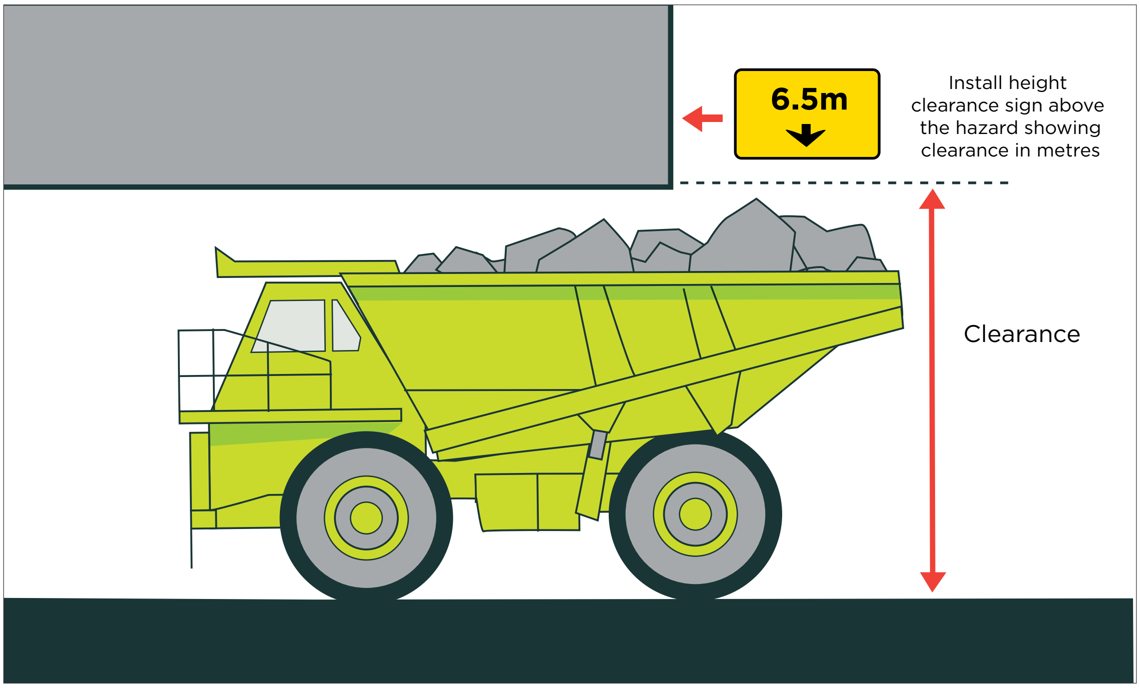



**Figure 57:** Example clearance signage and placement

## 11.3 REVERSING, MANOEUVRING AND PARKING

Reversing is hazardous because the driver has reduced visibility and is in an awkward driving position.

The most effective way of reducing reversing incidents is to use one-way systems and turning bays. Where this is not practicable, organise sites to keep reversing to a minimum. Where reversing is necessary, consider the following:

> ensuring adequate visibility for the driver
> installing engineering controls (ie collision avoidance equipment)
> installing reversing cameras, proximity detection equipment and reversing alarms
> providing safe systems of work
> providing adequate supervision and training.

Where safe reversing relies on reversing aids (such as reversing cameras) the vehicle should not be used if they are defective. Temporary controls could be used to ensure safety (eg using a spotter).

When it is dark, site lighting and vehicle lights must provide sufficient light for the driver to see clearly when reversing[57].

No single safeguard is likely to be sufficient on its own during reversing. Consider all the relevant precautions together (see Table 8).

| TYPE OF CONTROL | EXAMPLES OF CONTROLS |
|---|---|
| **Eliminate need to reverse** | > Implement one-way systems around site and in loading and unloading areas<br>> Provide designated turning areas |
| **Engineering controls** | > Fit collision avoidance equipment that warns the operator of the presence of a pedestrian, object or another vehicle and stops the vehicle from operating |
| **Reduce reversing operations** | > Reduce the number of vehicle movements as far as possible<br>> Instruct drivers not to reverse, unless absolutely necessary |
| **Adequate visibility and proximity devices for drivers** | > Fit reversing cameras, radar, convex mirrors and so on to overcome restrictions to visibility from the driver's seat, particularly at the sides and rear of vehicles<br>> Fit proximity devices to warn the driver of possible collision with an object or person |
| **Make sure safe systems of work are followed** | > Design vehicle reversing areas which:<br>– allow adequate space for vehicles to manoeuvre safely<br>– exclude pedestrians<br>– are clearly signed<br>– have suitable physical stops to warn drivers they have reached the limit of the safe reversing area<br>> Make sure everyone on site understands the vehicle rules<br>> Fit all vehicles on site with appropriate warning devices such as reversing alarms<br>> Have controlled (or supervised) reversing systems such as the excavator operator controlling the truck coming in to be loaded<br>> Use spotters<br>> Check that procedures work in practice and are actually being followed |

**Table 8:** Control measures for reversing options

### 11.3.1 SPOTTERS

A spotter's (or signaller's) job is to guide drivers and make sure reversing areas are free of pedestrians or other hazards.

If you are using spotters, make sure:

> only trained spotters are used
> they are clearly visible to drivers at all times
> a clear and recognised system of communication is adopted
> they stand in a safe position throughout the reversing operation.

[57] *Health and Safety in Employment Regulations 1995,* regulation 4 (2) (e)

### 11.3.2 FOLLOWING DISTANCES

Ensure vehicles follow one another at a distance that provides adequate clearance. If a vehicle follows another vehicle too closely, an accident can occur if the driver in the trailing vehicle doesn't react as fast as the lead driver to a stop situation. This can also happen if the trailing vehicle cannot stop as effectively as the lead vehicle.

As vehicle speeds increase, the following distance should be lengthened to provide the necessary level of safety. Drivers should increase their following distance in conditions where the sight distance is reduced (ie foggy conditions) or when road conditions may result in a longer stopping distance (eg in wet weather).

Consider the speeds on both level roads and grades, and establish following distance rules that provide for safe distances in all situations. The following distance rules should be kept in the site Traffic Management Plan or the Roads and Other Vehicle Operating Areas PHMP.

Visual aids can be used to determine following distances (eg spacing road marker pegs at the site's following distance rule).

### 11.3.3 STOPPING DISTANCES

The distance a vehicle needs to be able to stop is made up of three elements:

> the distance travelled during the operator's reaction time
> the distance travelled during the brake's response time
> the distance the vehicle travels before coming to a stop.

Quite often the Original Equipment Manufacturer (OEM) will only specify braking distance as specified in element 3.

The distance of the sum of all three elements should be allowed for when determining the overall stopping distance for vehicles. Gradients and wet conditions will also have a significant effect on element 3, and should always be factored into calculations which are provided in OEM braking data.

The load on a vehicle, traction, and how the brakes have been applied (soft, medium, hard) also affect the stopping distance of a vehicle.

In areas where excessive stopping distances are calculated, speed restrictions may be required to make sure the final calculated stopping distance meets acceptable operational requirements.

### 11.3.4 PARKING

Park vehicles on level ground wherever practicable to eliminate the possibility of them being set in motion. Vehicles parked on slopes should never be left unattended unless the wheels are secured, chocked, blocked or angled against a suitable bund so the vehicle cannot move accidentally.

You should develop a safe system of work for leaving a vehicle unattended. For example, requiring drivers to switch off the engine, remove the ignition key, apply all brakes and so on. For mobile plant this may include lowering ground engaging equipment (ie excavator buckets, dozer blades, ripper teeth and scraper bowls) to the ground.

Vehicles should never be parked in the swing radius of an excavator or the manoeuvring zone of other operational vehicles, unless in accordance with a safe system of work. When it is necessary to park light vehicles close to heavy vehicles (eg for maintenance purposes) the heavy vehicle should be parked before the light vehicle enters the area. The heavy vehicle should remain immobilised throughout the operation. An isolation procedure should be followed.

SSEs must ensure vehicles are only operated by competent people unless adequately supervised. Mine operators must authorise competent people in writing. This may mean ensuring keys, or any other devices for starting vehicles, are in a secure place while parked.

You must establish a safe system of work so anyone leaving a vehicle does not enter a hazardous area. This includes when operators are undertaking daily start-up inspections and shift changes.

## 11.4 LOADING VEHICLES

Loading, for the purposes of this section, refers to the loading of vehicles with excavated material by mobile plant. For information on safety when loading mobile plant or equipment (or other loads) from transporters or trucks, see the New Zealand Transport Agency's *The Truck Loading Code*. For information on loading floating plant see section 10.5.

Depending on the nature of the site, loading may be into haul trucks, truck and trailer units, utility vehicles or car trailers (eg where selling of product is directly to the public).

### 11.4.1 LOADING ZONES

It is recommended that the loading zone (or prohibited zone) be a minimum of six metres around the truck, trailer or mobile plant. This zone may need to be larger, depending on the visibility of vehicles or traffic movement associated with loading (refer Figure 58).

In addition to the loading zone, restricted zones should be established based on a site specific risk assessment which considers the movement of vehicles associated with loading.

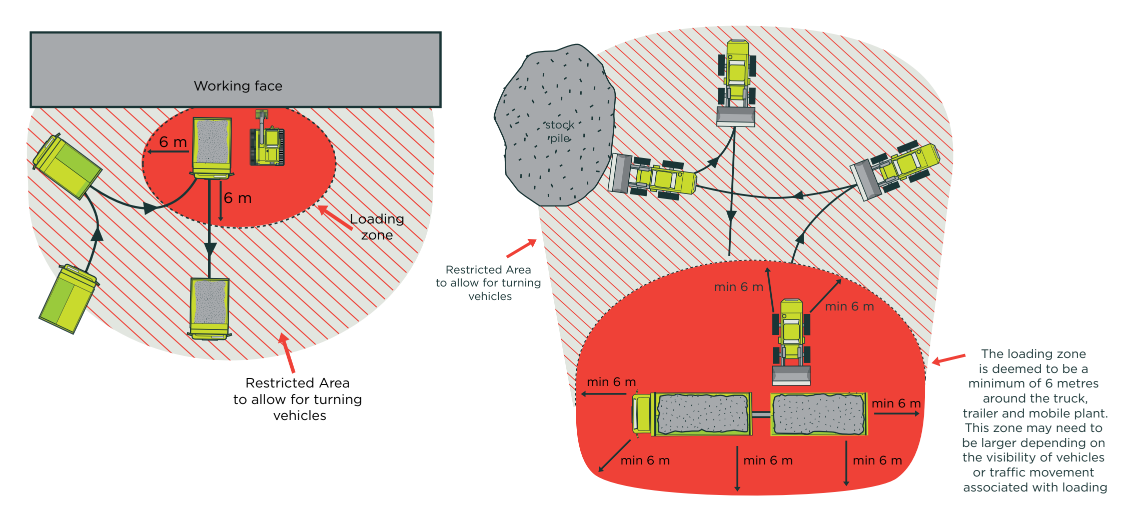



**Figure 58:** Loading and restricted zones

The entry of any vehicle (other than those being loaded) or pedestrians into a loading zone while excavation and loading operations are active should be prohibited.

You should determine a safe system of work which specifies communication protocols for vehicles entering the loading zone (to be loaded). For example, the system could specify contact is made with the mobile plant operator to request permission to proceed. On larger sites this may be co-ordinated by a supervisor or other designated person in control of traffic movements.

The safe system of work should also specify steps to be taken, including the immediate suspension of works, if a vehicle or pedestrian enters the loading zone without prior permission.

### 11.4.2 LOADING OPERATIONS

The *HSE Act* requires duty holders to identify and control significant hazards. Insecure loads and overloaded vehicles can present a significant hazard whether on a public road or a road within the confines of the site.

The *Land Transport Act 1998* contains the load security legislation for vehicles driven on public roads. It provides strict liability for offences involving insecure loads and loads falling from vehicles. *The Truck Loading Code* details the general requirements that must be met to ensure a load cannot fall, and applies to the operator or any person loading the vehicle.

Loads must be secured and remain safe while loading, while the vehicle is being driven, and during unloading. When loading or unloading, the vehicle should be level, stable and stationary. Apply all vehicle and trailer brakes, and follow these principles:

LIGHT VEHICLES

> Spread loads as evenly as possible during loading. Unbalanced loads can make the vehicle or trailer unstable, or overload individual axles.
> Prohibit loading over cabs unless the driver is out of the vehicle and away from the loading zone (ie in a safe area).
> Avoid loading to the back of the trailer as this can cause the trailer to tip backwards (especially for single-axle trailers). This can reduce the grip the vehicle has on the road surface, as the wheels are lifted away from the ground.
> Balance loads across the axle (or axles) of a drawbar so coupling or uncoupling can be managed easily and safely, and the trailer is stable when being transported.
> Wherever possible couple (or uncouple) drawbar trailers unloaded, as this makes them easier to handle and generally safer to work with.
> Select suitable mobile plant or purpose-built devices (hoppers) that reduce the risks to other vehicles or pedestrians.

ON-ROAD VEHICLES

> Spread loads as evenly as possible during loading, based on advice from the driver, and do not load over cabs. Unbalanced loads can make the vehicle or trailer unstable, or overload individual axles (see Figure 59).
> All drivers (and where applicable, passengers) should remain in the vehicle during loading.
> If the load is to be covered, an on-vehicle covering device that can be worked from ground level or a safe place higher up should be provided. Alternatively, a load covering platform or gantry should be used. For more information on covering loads refer section 16.3.
> As loose loads normally rely on the vehicle body for restraint it is extremely important to make sure all body-to-chassis attachment points (ie 'U' bolts, hinge pins, hinge pin brackets and so on) are secure, and the attachment points and body are in sound condition.
> Doors to bulk bins must be closed to avoid loose bulk loads from being blown out[58].
> When travelling on a public road, loose bulk loads should be covered whenever there is a risk of load shedding due to wind action or movement. Body work should be kept in good condition in order to minimise hazards during transportation. This applies particularly to badly fitted tail gates that permit gravel and stones to fall to the roadway.[58] Loose bulk loads being transported in a vehicle on a public road without a tarpaulin fitted, should at no time reach higher than 100 mm below any side of the vehicle (refer Figure 60)[58].

[58] The Truck Loading Code – specialised requirements (Loose bulk loads)

> Body height extensions (hungry boards) should only be used where conditions and type of load permit. In these circumstances, supports should be adequately fixed to the existing body. It is not adequate to rely on the load within the parent body of the vehicle for support. Where necessary, tie-chains should be used transversely at the top of body extensions to prevent sideways spread[58].

**Figure 59:** Loads should be spread evenly across the vehicle

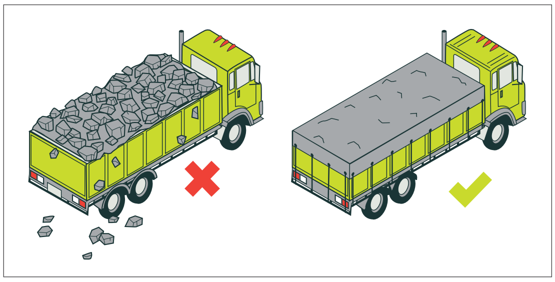


**Figure 60:** Cover loose bulk loads when travelling on a public road

OFF-ROAD VEHICLES

> Spread loads as evenly as possible during loading. Unbalanced loads can make the vehicle or trailer unstable, or overload individual axles.

> Prohibit loading over the cabs.

> All drivers (and where applicable, passengers) should remain in the vehicle during loading.

> Loads should not be dropped from height to avoid people in the cab being thrown around or injured.

> If particularly large rocks are being loaded, placing a fine material bed will provide some cushioning and stability.

> The placement of loads should ensure they are secure.

> The excavator or loader should be matched to the size of the truck being loaded.

### 11.4.3 WEIGHT LIMITS

Maximum vehicle and axle weights must never be exceeded[59]. Overloaded vehicles can become unstable and difficult to steer, or be less able to brake.

Mining operations must include the maximum load that may be carried or towed by vehicles and equipment (whether by reference to weight, dimensions or other criteria) on their roads and other vehicle operating areas PHMP[60].

## 11.5 LOADING FLOATING PLANT

For information on loading floating plant see section 9.3.

## 11.6 LOADING AND STORAGE OF LARGE STONE SLABS OR BLOCKS

Transporting and storing large stone slabs or blocks carries a high risk of serious personal injury if not done safely. Due to their size and weight, such slabs or blocks are potentially unstable.

To ensure the safety of workers you must determine a safe system of work that includes:

> **Prohibition zones**: not allowing people into an area where a slab or block may fall during transport or lifting.

> **Written work instructions** (or standard operating instructions): workers must be given appropriate information, instruction and training on the dangers of large stone slabs or blocks and the need to follow safe systems of work.

> **Adequate supervision** by a competent person.

[59] The Truck Loading Code
[60] The Regulations, regulation 80(1)(n)

> **Always restraining slabs or blocks during loading or unloading operations** (whether from vehicles or from storage). This should include attaching and detaching straps, lifting slings and so on. This is especially important when poeple may be in the hazardous area where a slab may fall during lifting, and when loading or unloading vehicles (due to the variable and sometimes unpredictable effects of road camber or vehicle suspension).

> **Providing, maintaining, using and inspecting** appropriate certified lifting equipment and PPE.

> **Making sure** loads are secured from movement while being transported.

When using rack type storage systems they should be designed and certified to prevent slabs toppling over or slipping out from the base. Traditional "A" frame storage is not suitable in this context unless modifications have been undertaken that achieve the above goal.

## 11.7 FEEDING CRUSHERS

If the crusher is to be fed directly by a loader or excavator, then:

> standing pads should be suitable (stable) and high enough for the operator to monitor the feed hopper from the cab

> keep the ramp wide enough to allow for adequate edge protection on either side of the ramp as well as the travel of the vehicle when using wheeled loaders or trucks

> the maximum gradient of the ramp should be within the capability of the loading vehicle

> the last few metres of the ramp should be level so the vehicle is not discharging uphill. This helps operators monitor the feed. The vehicle will also be more stable

> make sure pedestrians and obstructions are kept out of the excavator swing radius or loading area.

## 11.8 RAILWAY SIDINGS

Where railing sidings enter a site:

> where practicable, have a means of locking siding entrances

> where practicable, have tracks separated from other operational areas

> have a safe system of work for communication about train arrival times and days (eg having the rail operator advise of train entrance at least 24 hours prior)

> make sure tracks are not obstructed and are kept clear of debris

> where appropriate, put signage in place advising of train arrival and other hazards.

## 11.9 SAFE DRIVERS AND VEHICLES

Drivers must be competent, or adequately supervised, to operate a vehicle safely and receive appropriate information, instruction and training for the make and model of vehicles they use. It is particularly important that less experienced drivers are closely monitored following their training to make sure they work safely.

Protocols should be established that stipulate drivers and passengers must wear their seatbelts. Past accidents have shown that staying in the cab with the seatbelt fastened is the best way to avoid a serious injury or death when a vehicle goes out of control.

### 11.9.1 TRAINING AND COMPETENCY OF DRIVERS

Drivers must be licenced to drive on a public road. You should have internal systems of licencing for site areas not defined as a public road.

Training requirements will depend on an individual's experience and training they have previously received. Risk assessment should help decide the level and amount of training a person receives.

In general, newly recruited drivers have the greatest training needs but there should also be a reassessment programme for more experienced drivers.

It is important to assess information provided by newly appointed drivers, particularly in relation to training and experience. Monitor them on-site to establish both their actual level of competence and any further training needs.

Keep a record of training and licences for each driver to help ensure the most appropriate person is allocated a particular task, and identify those requiring refresher training.

Mine operators must authorise vehicle operators or drivers in writing[61]. Authorisation to operate should be for every individual vehicle and model.

For more information on training and supervision see section 20.

### 11.9.2 FITNESS TO DRIVE

A person's fitness to drive a vehicle should be judged on an individual basis, but the aim is to match the task requirements with the fitness and abilities of the driver.

Pre-employment health assessments and on-going health monitoring should include assessment and monitoring that relates to an individual's ability to safely drive a vehicle (and undertake any associated tasks) where their role requires it.

Detailed advice on medical standards of fitness to drive is published by the NZTA: nzta.govt.nz/resources.

### 11.9.3 VEHICLE SUITABILITY

Vehicles must be suitable for the type of work being done and the place they are being used.

Selecting suitable vehicles can reduce or eliminate many risks at the site. It is generally much easier and cheaper to start with the right vehicle than to modify it later. The following are minimum factors to consider before purchasing a vehicle:

> the effectiveness of the braking system, bearing in mind the slopes it is expected to work on
> adequate all-round visibility for the driver
> stability under all foreseeable operating conditions
> protection for the driver and any passengers from falling objects (falling object protective structure (FOPS)), overturning (roll-over protective structure (ROPS)) and seat belts. Further information is available in the *Approved Code of Practice for Operator Protective Structures on Self-propelled Mobile Mechanical Plant*
> safe access and egress to and from the cab and other areas of the vehicle where access may be required
> engine firewall and fire suppression equipment
> lights, windscreen wipers, horn and other warning devices
> guarding for dangerous parts during use or maintenance work
> protection for the driver and any passengers from rain, high and low temperatures, noise, dust and vibration
> suitable seating for the driver and any passengers
> maximum loads that may be carried or towed.

Where vehicles are not fitted with safety features you must consider retro-fitting where your hazard identification and risk assessment process has recognised a significant hazard.

For vehicles expected to enter sites in the hours of darkness (whether or not work

[61] The Regulations, regulation 121

is scheduled to take place) additional supplementary lighting should be provided (ie forward and rearward facing spotlights) or additional vehicle-mounted work lights. Any permanently fitted lights must comply with the *Land Transport Rule: Vehicle Lighting 2004* when being driven on public roads.

### 11.9.4 DRIVER VISIBILITY

Many vehicles have substantial blind spots, not only immediately behind the vehicle, but also alongside and immediately in front of it. Improving visibility requires a combination of approaches such as reversing cameras, collision avoidance systems, proximity sensors and mirrors.

Studies suggest that when used appropriately (ie drivers glance at the system at the appropriate time) reversing cameras can successfully mitigate the occurrence of reversing crashes, particularly when paired with an appropriate audible warning system. One study[62] found:

> of those drivers that did not look at the rear-view camera before reversing, 46% looked at the camera after being audibly warned

> of the drivers who looked at the rear-view camera display 88% avoided a crash.

Accidents can occur when vehicles drive off or turn while a pedestrian or vehicle is passing or parked in a blind spot. As a guide the driver should be able to see a one metre high object one metre away from any danger point of a vehicle. The driver should be able to detect the presence of other vehicles and pedestrians in their intended line of travel when moving off or when reversing.

Tests carried out for the National Institute for Occupational Safety and Health (NIOSH) demonstrate blind areas in some typical mining vehicles. The illustrations in the report show the area around the operator where they cannot see obstacles. You can download the report or view the diagrams on-line at www.cdc.gov/niosh/topics/highwaywork zones/bad/pdfs/BASFinalReport.pdf.

There should be a procedure to be followed before a vehicle drives off. This should be a beep from the horn, with a five second delay before driving off, from being parked overnight or otherwise not in use. In operational areas this should be two beeps from the horn, with a five second delay before driving forward, and three beeps from the horn with a five second delay before reversing.

#### A CLEAR VIEW

Drivers should not place items in the windscreen or in the way of mirrors or monitors, where they might impede visibility from the driving position. The area of the windscreen that is kept clear by the wipers should not be obscured, nor should the side windows. Windows and mirrors should be kept clean and in good repair. Dirt or cracks can make windows or mirrors less effective. If necessary, fit additional side-mounted mirrors to increase the driver's visibility (refer Figure 61 and Figure 62).

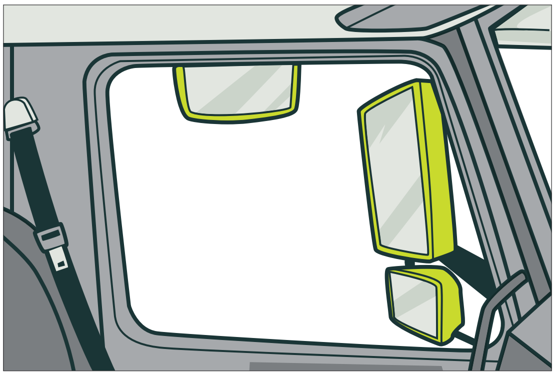


**Figure 61:** Side-mounted mirrors

[62] Backing collisions: A study of drivers' eye and backing behaviours using combined rear-view camera and sensor systems, Hurwitz DS. et al (2010), Injury Prevention 16(79-84)

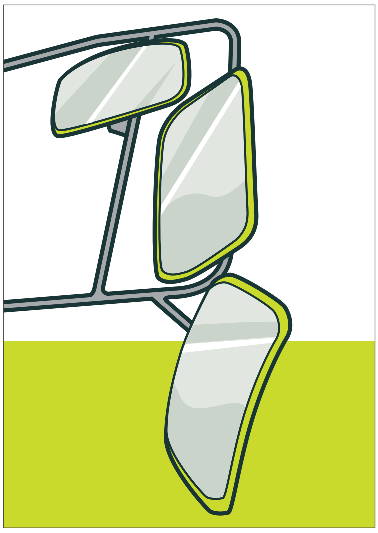


**Figure 62:** Side-mounted mirrors

COLLISION AVOIDANCE AND PROXIMITY DETECTION EQUIPMENT

Collision avoidance equipment warns the driver of fixed obstacles or other vehicles along the route, and stops the vehicle from colliding. Collision avoidance systems usually use GPS or local area wireless technology (ie WiFi or Bluetooth) to determine vehicle position, speed and heading. Vehicle locations and paths are calculated and sent via a radio link to all other outfitted vehicles in the area. Where two or more vehicles may collide audible and visual warnings are sent to the drivers.

Proximity detection equipment warns the driver of the presence of people or objects in the immediate vicinity, but does not stop the vehicle from colliding (it relies on the driver to stop).

CLOSED-CIRCUIT TELEVISION (CCTV)

CCTV cameras can be mounted on the front, side and rear of a vehicle. Images are relayed to a screen located inside the cabin (refer Figure 63). Some cameras are equipped with infrared illuminators so the driver has a comprehensive view even when it is dark.

Thermal imaging systems are also available and may be suited to sites where night operations are a concern.

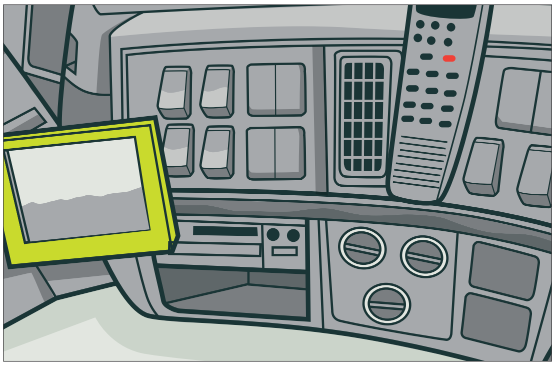


**Figure 63:** CCTV monitor in vehicle cab

REVERSING ALARMS

Reversing alarms warn anyone in the vicinity the vehicle is in reverse gear. They rely on the driver having a clear view and the pedestrian or other vehicles moving out of the way.

Reversing alarms may be drowned out by other noise, or may be so common on a busy site that people do not take any notice of them. Using reversing alarms may be appropriate (based on your risk assessment) but will likely be most effective when used with other measures.

### 11.9.5 VISIBILITY OF LIGHT VEHICLES

Light vehicles are at risk of being crushed by heavy vehicles. They should be kept away from areas where heavy vehicles operate. Where this is not practicable they should be fitted with rotating or flashing beacons, high visibility 'buggy whips', high visibility and reflective markings and other appropriate measures. This makes them readily visible to drivers of other vehicles. The use of vehicle hazard lights alone is not deemed adequate and should be discouraged.

For light vehicles expected to enter areas where heavy vehicles are operating, consider the following controls during your risk assessment:

> Establish exclusion zones around heavy vehicles.

> Heavy vehicles are to remain stationary when light vehicles are within exclusion zones.

> The impact on environmental conditions on visibility (eg darkness, fog or rain).
> Fit vehicles with rotating or flashing orange warning lights, visible 360 degrees from the vehicle, unless multiple lights are fitted to cover blind spots and fit with reflective strips.
> Fit radios so drivers can communicate with site supervisors or directly to heavy vehicle drivers.
> Fit a warning flag (buggy whip) which can be seen by the operator of the tallest vehicle.
> Fit clearly visible numbering, or an alternative form of positive identification, as an aid for 2-way communication between heavy vehicle and light vehicle drivers.

Light vehicle visibility controls should apply to all light vehicles (eg contractor or visiting drivers where they are required to enter operational areas).

Any permanently fitted lights, retro-reflectors or retro-reflective material must comply with the *Land Transport Rule: Vehicle Lighting 2004* where being driven on public roads.

### 11.9.6 PROTECTION OF DRIVERS, OPERATORS OR PASSENGERS

OPERATOR PROTECTIVE STRUCTURES

Operators of heavy vehicles are at high risk of serious or fatal injury by crushing if their vehicles roll over, tip on to their sides or objects enter the cab.

Generally, the risk depends on the terrain. There's a low risk on flat, stable ground and high risk on steep or unstable ground, or on work adjacent to embankments, excavations or working on top of old mine workings.

Fitting ROPS and wearing a seat belt can reduce the risk of serious or fatal injury in the event of a roll-over or tip-over. Where there is risk of objects falling onto the operators or entering the driving position (such as rock falls) the operator also needs the security of a falling object protective structure (FOPS).

Mining operations are required to address the fitting of devices to protect the operators of mobile plant, including rollover protection and falling object protection (refer regulation 98 Mechanical Engineering Control Plan).

For more detailed information on design and types of operator protective structures, see the *Approved Code of Practice for Operator Protective Structures on Self-Propelled Mobile Mechanical Plant.*

SEAT BELTS

All drivers and passengers should wear appropriate seat belts. They should be checked immediately if:

> the buckles are not working properly
> the belt is damaged or faded
> the belt starts to fray.

Specific legal requirements under the Land Transport Act for safety belts have changed over the years, and differ depending on the age and type of vehicle. The type of belt has also changed from static belts to retractor belts. For more detailed information on seat belts for vehicles, see the New Zealand Transport Agency website nzta.govt.nz. The information from NZTA is considered good practice regardless of whether the vehicle is being driven on a public road or not.

For more detailed information on seat belt requirements for vehicles fitted with operator protective structures see the *Approved Code of Practice for Operator Protective Structures on Self-Propelled Mobile Mechanical Plant.*

TRANSPORTING PEOPLE

People should only be transported in vehicles designed to carry passengers with forward or rear facing seats and seatbelts. These vehicles should also comply with vehicle visibility standards (see section 11.9.4). Vehicles not specifically designed for carrying people should not be used.

Wherever practicable, carry loads separately from passengers. If the cab is not separate from the load area (eg a van), fit a bulkhead or cargo barrier between the load compartment and the cab. This should be strong enough to withstand a load shifting forwards in an emergency.

Secure small equipment (ie fire extinguishers or tools) which may become missiles in the event of a collision.

### 11.9.7 VEHICLE FIRES

Typical causes of fires on or in vehicles include component failure and poor or inadequate maintenance. When completing a risk assessment for prevention of fires consider:

**The design** – for example:

> Hydraulic components are 'like for like' and considered suitable for use. Always consult the original equipment manufacturer(s) (OEM) before making changes.

> Any maintenance, installations or design modifications that are undertaken off-site are verified before use, and are equivalent to the OEM's standards and design.

> Implementing quality checks or audits by OEM authorised service providers periodically as a cross check for site maintenance.

> Using Low Flammability Hydraulic Fluids. **Note:** Low flammability and mineral hydraulic fluids should never be mixed. If you are replacing one with the other ensure a flushing product is used and no residual product remains.

**The installation** – for example:

> properly fitting any attached or in situ hoses with approved OEM components

> maintaining hydraulic equipment with the appropriate fit-for-purpose tools

> routinely checking hose clamps for security

> routinely checking for wear of hoses or rigid pipes underneath clamps

> using fire resistant hoses and high temperature tolerant hoses designed for oil operating temperatures >150°C

> installing and evaluating insulation around hot components or insulating hoses near hot components and upgrading to braided armour type hoses

> protecting wiring against fire and making sure connections are appropriate to OEM's requirements and are suitably located

> the location and rating of protective devices such as fuses, solenoids and non-return valves.

**Inspection and maintenance** – for example:

> completing pre-start checks for locating and acting on oil leaks, sprays, stains and bird nests

> the maintenance work order system includes the correct selection, integrity and testing of control measures

> using thermal imaging equipment to detect hot spots and high temperature areas of plant during maintenance programs

> routinely washing, cleaning and checking hoses for any sources of rubbing, oily mist or leaks

> carrying out periodic checks on hydraulic braking systems to ensure sound operation, including bearings brake drums, rotor and callipers

> routinely checking electrical wiring including insulation

> routinely checking solenoid connections for corrosion and replacing or checking at set engine hours or as per OEM recommendations

> protective devices for solenoids such as fuses.

**Emergency preparedness** – for example:

> Installing suitable and sufficient firefighting equipment (ie fire extinguishers). The type of fire extinguisher will depend on the class of fire you are most likely to experience. For example, powder ABE fire extinguishers are suitable for flammable and combustible liquids, flammable gases and energised electrical equipment.
> Communication of fire-related events, maintenance incidents and subsequent attendance and associated follow-up, is clear to workers.
> Fitting appropriate automatic or manually operated fire suppression, and engine or fuel pump shutdown systems[63].
> Fitting mobile plant with a battery isolation switch and where practical, a fuel isolation system.

## 11.10 MAINTENANCE AND REPAIR OF ROADS

Roads and other vehicle operating areas should be regularly maintained so they do not develop bumps, ruts or potholes. These may make control of vehicles difficult or cause health problems due to whole body vibration. In addition, excess mud and slurry can seriously affect the manoeuvrability and braking potential of the vehicles using the road and other vehicle operating areas.

### DUST SUPPRESSION

Dust generated by moving vehicles can reduce visibility to dangerous levels and introduce a health hazard. Dust is typically reduced by applying water to the road surface. In dry conditions, watering helps maintain compaction and surface pavement strength. It also maintains the pavement shape, reduces the loss of gravel and helps reduce corrugation of the road surface.

The quantity of water needed to control dust depends on the nature of the road surface, traffic intensity, humidity and precipitation. During drier months, a typical road may require one to two litres per square meter per hour. Liquid stabilisers and polymers can also be used, which can help strengthen the surface layer and provide a degree of water proofing.

### SAFETY WHEN WATERING ROADS

Watering roads to suppress dust has the potential for vehicle accidents. The water tanker could turn over or the roads could become slippery because of wet bends, downgrades, and any other sections of road where brakes may be applied (ie intersections).

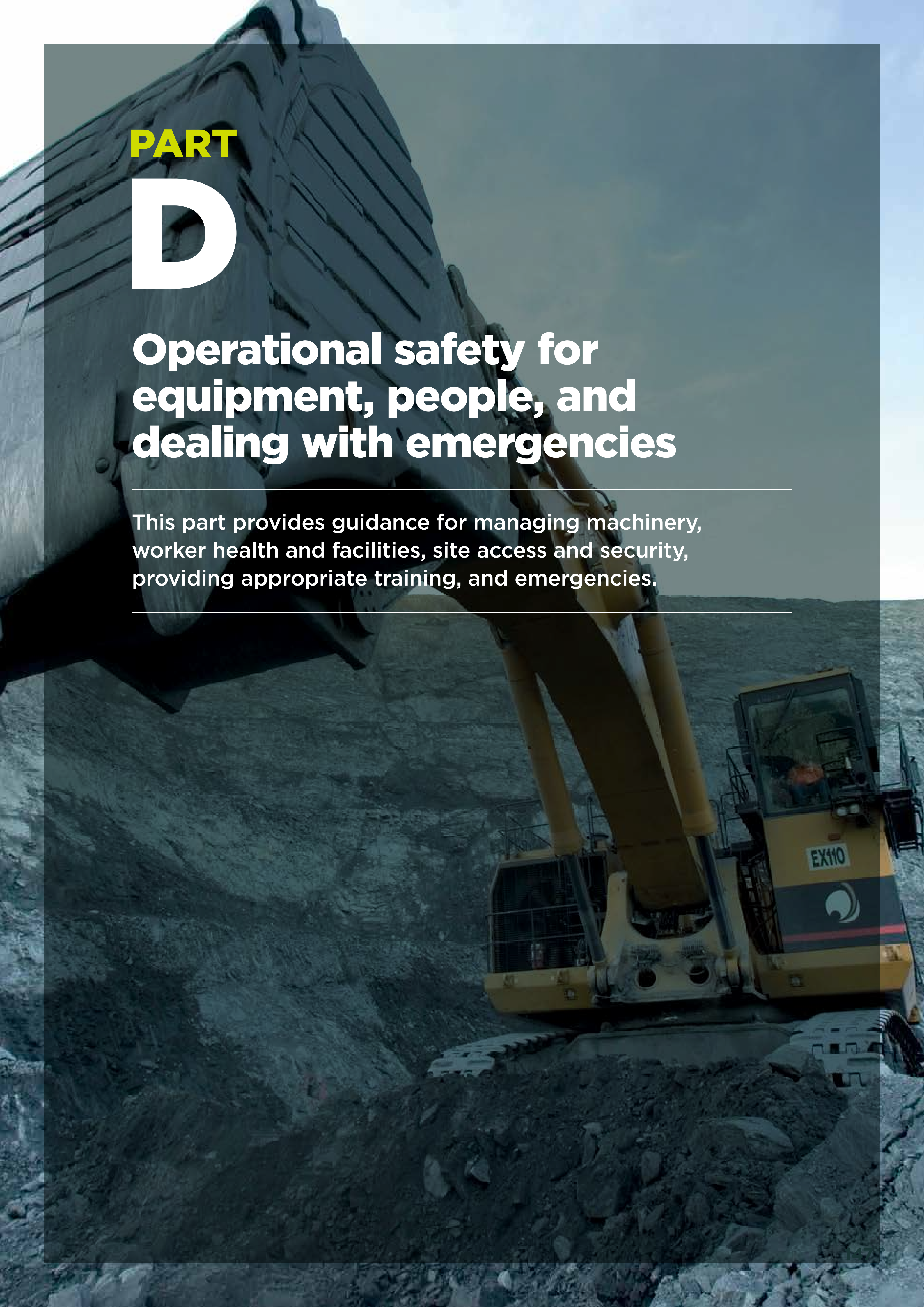
Water tanker drivers should avoid driving across gradients due to the potential increase in instability of trucks carrying fluids. As a hazard control, consider installing baffles in tanks carrying fluids to help prevent movement of water inside the tank.

'Patch' or 'spot' spray roads, and avoid blanket spray or excessive amounts of water being deposited on the roads (especially in braking areas, gradients and junctions of haul roads). It is recommended water tankers are fitted with systems that can be effectively controlled by the operator to manage water output.

Procedures for watering roads should detail actions to take when roads have been excessively watered, reducing traction. This is particularly important on haul roads.

Where possible, water tankers should be filled at the lowest point, and dust suppression applied travelling up hill. This will avoid fully loaded water tankers travelling downhill.

[63] The Regulations, regulation 98 (d) – Automatic fire suppression and engine or fuel pump shutdown systems for safety critical equipment must be addressed by mining operations in their Mechanical Engineering PCP



# PART D

# Operational safety for equipment, people, and dealing with emergencies

This part provides guidance for managing machinery, worker health and facilities, site access and security, providing appropriate training, and emergencies.

PART D

# 12/

## MACHINERY AND EQUIPMENT

IN THIS SECTION:


12.1 Scope

12.2 Appraisal of machinery and equipment principal hazards

12.3 Mechanical engineering or electrical engineering control plan

12.4 Choosing and buying machinery and equipment

12.5 Existing machinery or equipment

12.6 Siting of Machinery

12.7 Access routes

12.8 Guarding

12.9 Conveyors

12.10 Emergency stops

12.11 Pre-start warning systems

12.12 Electricity

12.13 Cranes and lifting equipment

## All sites use machinery and equipment in their day to day workplace activities. If the hazards associated with machinery are not safely managed, then serious injury and death can occur.

The overall message is – **safety by design**.

This section describes how to:

> identify and manage equipment hazards (for new and existing equipment)

> position and guard equipment

> use prestart warning systems and emergency stop systems effectively

> prevent, detect and deal with fires and explosions

> manage electrical hazards

> manage specific hazards around lifting equipment and floating equipment.

## 12.1 SCOPE

The scope of 'machinery' and 'plant' as defined in the *HSE Act* is extremely wide. It covers almost any equipment used at work including:

> hand tools such as hammers, handsaws

> individual machines such as circular saws, photocopiers, trucks

> apparatus such as laboratory apparatus (eg Bunsen burners)

> lifting equipment such as hoists, forklifts, elevating work platforms, lifting slings

> other equipment such as ladders, pressure water cleaners

> an installation (a series of machines connected together), for example a crushing plant and associated conveyor systems.

This section covers machinery and equipment commonly used at extractives sites where the information in the following documents, or other WorkSafe guidelines, may not be sufficient to provide industry specific guidance. This section does not cover vehicles including mobile plant (for information on vehicles see section 10).

The *WorkSafe Best Practice Guidelines for the Safe Use of Machinery* and *Ergonomics of Machine Guarding Guide* have information for managing hazards associated with machinery which may not be covered in these guidelines including:

> undertaking risk assessments

> choosing, buying, installing, modifying and decommissioning machinery

> eliminating hazards in the design process

> specific machinery hazards

> guarding types

> use, inspection and maintenance of machinery

> safe systems of work.

The *WorkSafe Approved Code of Practice for Managing Hazards to Prevent Major Industrial Accidents* outlines information for processes employed after crushing and screening (eg bitumen production or ore processing) that is not included in these guidelines. Appendix 2 of the code lists activities the code may apply to.

## 12.2 APPRAISAL OF MACHINERY AND EQUIPMENT PRINCIPAL HAZARDS

**66 Site senior executive responsible for identifying principal hazards and having principal hazard management plans**

(a) The site senior executive must-

- (a) carry out an appraisal of the mining operation to identify principal hazards at the mining operation; and
- (b) ensure there is a principal hazard management plan for each principal hazard identified.

To determine if activities associated with machinery and equipment are principal hazards, it is necessary to consider the following:

- > how plant, equipment or installations might feasibly fail and the likely consequences of any such failure (ie structural support collapse)
- > the type of fuel or energy used to power plant, equipment or installations used at the site (ie electricity, gas, petroleum)
- > what the possible consequence of a loss control situation would be (ie mechanical failure leading to uncontrolled release of hazardous substances or energy sources)
- > the hazards relating to moving parts (ie draw-in hazards, nip points, entanglement hazards)
- > the hazards relating to suspended parts
- > the hazards relating to surfaces (that is very hot or very cold).

If the degree of hazard is not clear the advice of a specialist mechanic, designer, engineer or the machinery or equipment's original manufacturer should be sought.

A risk assessment must be completed when developing the mechanical engineering PCP. The risk assessment must include the matters prescribed in regulation 97 of the Regulations.

## 12.3 MECHANICAL ENGINEERING OR ELECTRICAL ENGINEERING CONTROL PLAN

**PART 4**

PRINCIPAL CONTROL PLANS

**92 Site senior executive responsible for having principal control plans**

If a subpart of this Part applies to a mining operation, the site senior executive must ensure that there is a principal control plan for the mining operation that complies with that subpart.

Subpart 1 – Mechanical engineering

**96 Application**

This subpart applies to any mining operation where 1 or more principal hazards have been identified that may involve hazards or controls of a mechanical type.

Subpart 2 – Electrical engineering

**99 Application**

This subpart applies to-

(1) Any mining operation where 1 or more principal hazards have been identified that may involve hazards or controls of an electrical type.

Where one or more principal hazards have been identified that may involve hazards or controls of a mechanical type, the SSE must ensure there is a mechanical engineering control plan.

Where one or more principal hazards have been identified that may involve hazards or controls of an electrical type, the SSE must ensure there is an electrical engineering control plan.

The mechanical engineering control plan must contain information detailed in regulation 98 of the Regulations.

In summary, regulation 98 includes:

> the standards of engineering practice to be followed throughout the life cycle of the mechanical plant and installations
> the safe operation of conveyors, winding systems mobile plant and dredges
> the safety of plant and installations
> fitting appropriate fire suppression and shut-down systems
> fitting appropriate heat detection and automatic trip sensors
> rollover and falling object protection
> seatbelts and other restraints
> protective canopies
> safe storage and use of pressurised fluids
> means for the prevention, detection and suppression of fires on mobile plant and conveyors.

The electrical engineering control must contain information detailed in regulation 100 of the Regulations. In summary, regulation 100 includes:

> prevention of harm from electricity sources
> prevention of fires being started by electricity
> prevention of unintentional starting of electrical plant
> fitting electrical safeguards
> competencies required for workers carrying out electrical work
> the reliability of plant and installations used in monitoring hazard controls and communication systems
> a maintenance management system
> safe work practices for working on high voltage installations
> any other requirements of the *Regulations* in relation to the safety management of electrical plant and installations and electrical engineering practices
> the requirements of regulations made under the *Electricity Act 1992.*

Develop the mechanical engineering and electrical engineering control plans in the context of the whole health and safety management system. It should not be developed in isolation from other plans, processes and procedures that rely on the control plans as a control. This will ensure gaps and overlaps in information and procedures are identified and used in the implementation of suitable controls to minimise the likelihood of potential risks and impacts.

Machinery and equipment may also constitute a fire or explosion principal hazard. Therefore, a PHMP for Fire or Explosion may also be required (refer to regulation 85 of the Regulations).

For more detailed information on the content of principal control plans, and their interdependencies with other management and controls plans, processes and procedures see WorkSafe's *Guidance for a Hazard Management System for Mines*.

## 12.4 CHOOSING AND BUYING MACHINERY AND EQUIPMENT

The greatest opportunity to ensure machinery and equipment is safe is when new machinery or equipment is being scoped, designed and purchased. All operators should specify their expectations for achieving safety standards.

The designer, manufacturer, supplier and employer have obligations under the *HSE Act* and the *Health and Safety in Employment Regulations 1995* and should work together to manage issues such as:

> how the machine or equipment is used in the workplace
> risk levels and standards required
> type of guarding based on work patterns
> who will provide, install and commission the machinery or equipment
> integration with other machinery or equipment
> the working environment in which the machinery or equipment will operate

> any hazardous exposures arising from use of the plant or equipment such as noise or fumes
> who will train and supervise the operators
> operations and maintenance procedures
> intrusive maintenance and internal inspections required
> potential blockages or out of the ordinary situations
> how isolation from hazardous energy can be achieved.

Where the machinery or equipment is being designed and manufactured in-house, you take on the responsibilities set out in regulations 66 and 67 of the *Health and Safety in Employment Regulations 1995*. You (the designer) must have health and safety, including relevant standards, in mind when developing design concepts and throughout the design process.

If newly purchased machinery or equipment is not safe because of the way it has been designed, constructed, supplied or installed, you must stop using it until this has been fixed. Contact the manufacturer or supplier (or installer if relating to the installation) to resolve the issue.

## 12.5 EXISTING MACHINERY OR EQUIPMENT

With changes in technology and cost of solutions over time, measures to eliminate or isolate a hazard may become practicable. You should continue to assess significant hazards in order to determine whether there are other methods to control them. For example, replace a machine with a newer machine that eliminates the hazard. You should also routinely review systems, procedures and standards to reflect changes in technology and best practice.

You need to know what the hazards are with your machinery and equipment in order to do something about them. The first step in the hazard management process is to identify hazards – anything that can injure or harm someone.

Do a workplace inspection to identity all machinery and equipment used. Include common items that may not normally be thought of as 'machines'. Also consider how other workplace items such as steps or platforms can affect the use of machinery and equipment.

Once you've identified all machinery and equipment, you can identify their hazards. You can identify hazards using physical inspection, task analysis, process analysis, guidance and standards, hazard and operability analysis (HAZOP) and accident investigation analysis.

For more detailed information on identifying, assessing and controlling hazards see the WorkSafe *Safe Use of Machinery Best Practice Guidelines*.

## 12.6 SITING OF MACHINERY

As a general rule, activities such as crushing and screening are noisy and dusty, so are sited away from boundaries to lessen the nuisance value of the activities. Some noisy and dusty processes may need to be housed to control these effects.

The safety of workers in the processing area is paramount. Traffic should be routed around the machinery wherever possible and machinery should be sited away from hazards (ie rock falls, overhead power lines).

Services, including electricity, air and water should be included in a site layout plan, particularly when placed underground.

## 12.7 ACCESS ROUTES

Machinery, including mobile crushers, often have areas where access at height is required to carry out routine operations, undertake maintenance or access control rooms.

This section deals with permanent (or fixed) access requirements (ie access to control rooms). For temporary access see section 16.1.

Where a structure is a building under the *Building Act 2004*, you must provide reasonable and adequate access to enable safe and easy movement of people[64]. Access routes must, among other things:

> have adequate activity space
> be free from dangerous obstructions and from any projections likely to cause an obstruction
> have a safe cross fall, and safe slope in the direction of travel
> have adequate slip-resistant walking surfaces under all conditions of normal use
> include stairs to allow access to upper floors
> not have isolated steps (ie single steps).

Have landings of appropriate dimensions where a door opens from or onto a stair, ramp or ladder so that the door does not create a hazard[64].

Access routes must also have stair treads and ladders which:

> provide adequate footing
> have uniform rise within each flight and for consecutive flights
> have stair treads with a leading edge that can be easily seen.

Access routes must also have handrails which:

> are smooth, reachable and graspable to provide support and to assist with movement along a stair or ladder
> be of adequate strength and rigidity as required by Clause B1 "Structure" of the *Building Code.*

Even if your machinery may not be classified a building under the *Building Act*, WorkSafe recommends you follow the requirements of the *Building Act*.

For more detailed information on access routes, including detailed diagrams of dimensions and construction requirements for stairs, ladders, ramps, barriers and access ways, see the MBIE Building Programme *Compliance Document for New Zealand Building Code Clause D1 – Access Routes* and *Compliance Document for New Zealand Building Code Clause F4 Safety from Falling.*

Refer to NZS/AS 1657 for more information.

## 12.8 GUARDING

The fundamental principles of guarding machinery are covered in the WorkSafe *Safe Use of Machinery Best Practice Guidelines,* and *Ergonomics of Machine Guarding Guide*. More information is available on the machinery fact sheets on WorkSafe's *Safe Use of Machinery* page at worksafe.govt.nz.

Where elimination of a hazard is not practicable, guarding is an effective isolation control provided the guards are the correct ones, and they remain in place.

This section provides additional guidance on effective guarding on fixed and mobile processing plant typically found in quarries and mines. It is not intended to be a comprehensive list and you may determine other types of guarding are more suited to the particular circumstances at your site.

Perimeter fencing (or area guards), although commonly used at extractive sites, does not meet the minimum requirements of *AS 4024.1 Series* where workers require access within the perimeter while the machinery is running. In these situations fixed guards should be used to guard individual nip points and entanglement hazards.

[64] Building Code

Examples of fixed guards include:

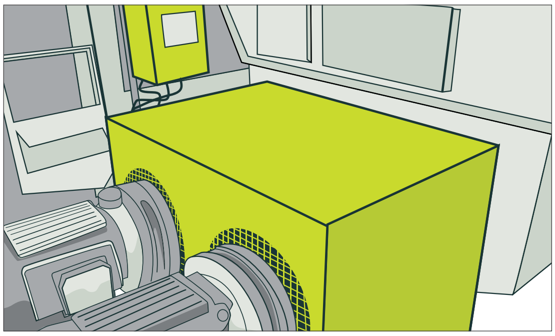


**Figure 64:** Example of fixed close-fitted guard enclosure on direct drive electric motors

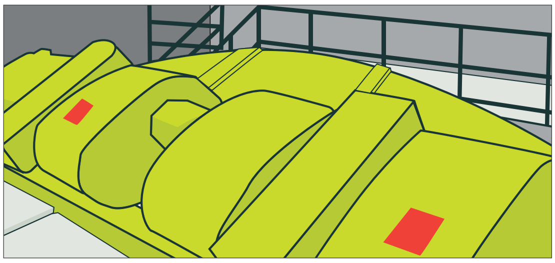


**Figure 65:** Example of totally enclosing sheet metal guard which are suitable for vibrating units with additional guards over the associated shafts and couplings

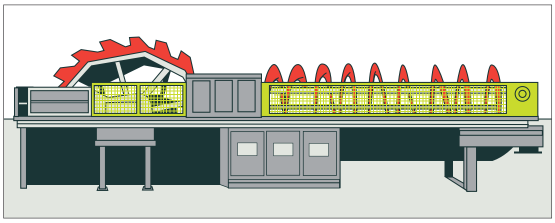


**Figure 66:** Example of panel mesh guards on fines dewaterer

Fines dewaterers use slowly rotating scraper blades to extract the finer particles. In addition to a sheet metal guard on the main dewatering section, a mesh guard should be provided around the trough of the scraper blade section. This should be fitted high enough to avoid workers falling into the trough or being able to reach the scraper blades and be at least 2.7 metres above ground level.

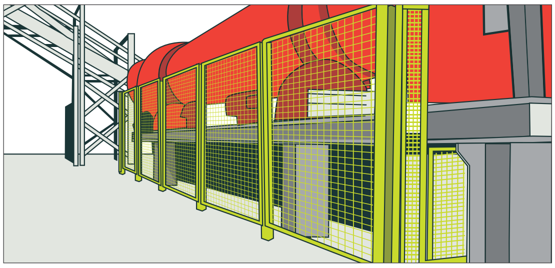


**Figure 67:** Example of panel type guards on dryer

Panel type guards secured to fixed uprights may be suitable for large rotating cylinders such as screens, dryers and trommels. The minimum height of the guard should be 2700 mm. Access gates should be interlocked unless access is required less than once per shift, in which case a locked gate can be used (must require a tool to open).

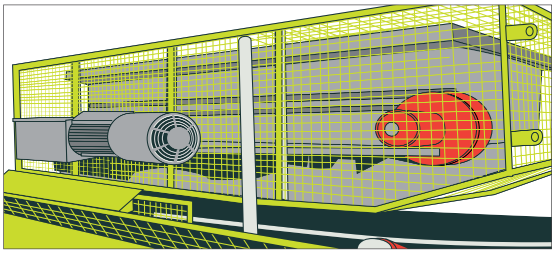


**Figure 68:** Example of close fitted guards on batch feeder belts

Batch feeder belts (while generally slower) have the same hazards as a normal conveyor. The feeder and all associated nip points should be enclosed within suitable guards fitted along the full length of the feeder. Guards should be provided on the underside to prevent access to tail and head drums.

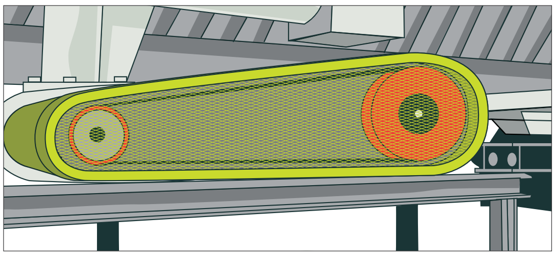


**Figure 69:** Example of close fitted guards on vee-belt drive

Vee-belt drives are commonly used on various items of plant. Open mesh guards help with efficient cooling of the vee-belts and pulleys and allow vee-belt tension to be visually checked without removal of the guard. The guard should fully enclose the front and back as required to prevent access.

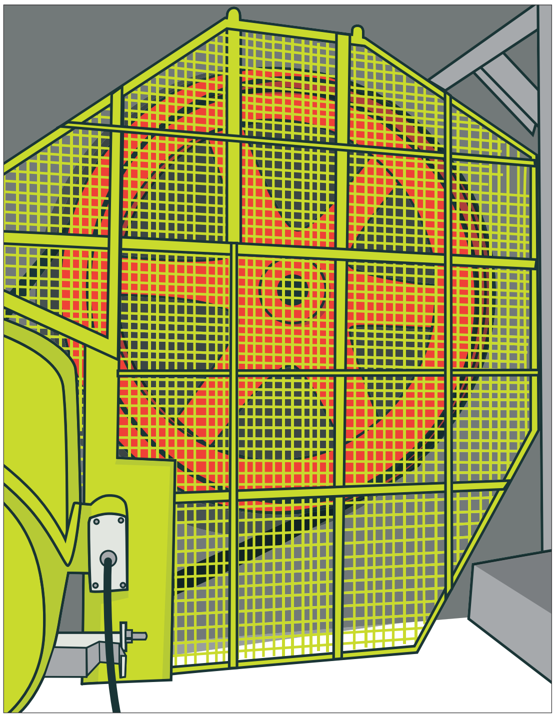


**Figure 70:** As with vee belt drives, a fixed guard totally enclosing the drive is suitable for primary jaw crusher drives. Alternatively guarding fitted around existing structures may be suitable

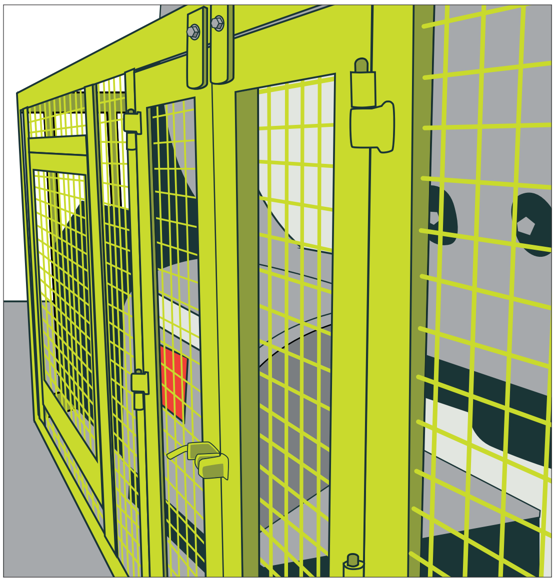


**Figure 71:** Example of hinged access panel guard bolted shut

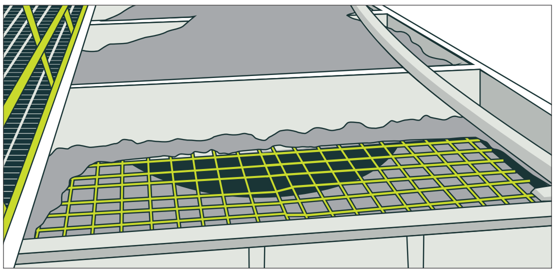


**Figure 72:** Example of steel man-grid on elevated feed hopper

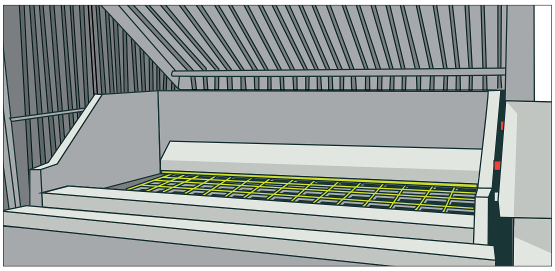


**Figure 73:** Example of steel man-grid on ground feed hopper

Steel grids, with sufficient strength to withstand any anticipated loads, should be provided in the top of all ground feed hoppers and easily accessible elevated feed hoppers. This is to prevent unauthorised or inadvertent entry. The exception is with primary hoppers or where products of a large dimension are being processed which may obstruct the grid.

Fitting grids on elevated hoppers may encourage people to walk on them next to an unprotected edge. Appropriate access prevention measures should be incorporated in the design (eg barriers).

Provision should be made to enable drivers at ground feed hoppers to release tail gate latches from a position of safety.

### 12.8.1 CONVEYOR GUARDING

Most serious accidents and fatalities with conveyors result from the machinery, and associated in-running nip-points, not being adequately guarded.

A wide variety of mechanical motions and actions on a conveyor system will present hazards to the worker. These can include the movement of rotating parts, moving belts, meshing gears, and any parts that impact or shear. These different types of hazardous mechanical motions and actions are basic in varying combinations to nearly all machines, and recognising them is the first step toward protecting workers from the hazards they present.

On a conveyor, in-running nip points are dangerous trapping points at the line of contact between the rotating drum or pulley (cylinders) and the moving conveyor belt on the in-running side of the cylinder. A similar point on the out-running side of the cylinder where the conveyor belt exits is not the dangerous location unless the conveyor can be reversed.

Even smooth, slowly rotating cylinders can grip clothing, and through skin contact alone force an arm, hand or body into a dangerous position. Frequently the machine is running too fast, or is too powerful to allow the person to stop the machine or pull the body part out. This can result in severe friction burns, amputation or significant (including fatal) crushing injuries.

Where a moving part cannot be eliminated, and workers are exposed to potential contact, fitting fixed barrier guards and additional in-running nip guards are practicable isolation controls.

Hazardous trap points may occur at the following locations:

> power transmission moving parts
> head and tail end pulleys
> bend, snub and take-up pulleys
> carrying and return idlers beneath feed hoppers, skirt plates and where the lift of the belt has been restricted as well as at convex curves (brow position)
> roller assemblies for conveyor belt tracking
> idlers accessible to people such as from crossovers or underpasses, maintenance or storage areas or cleaning areas and transition idlers adjacent to pulleys
> drive drums.

The following pages outline possible guarding for conveyor belt parts in operation, including:

> power transmission moving parts
> belts
> upper and lower strands in a straight run
> curved zone (brow positions)
> head and tail drums and transition zones
> gravity take up units
> fixed obstacles
> skirt boards.

It also provides general information on the use of nip guards.

#### POWER TRANSMISSION MOVING PARTS

Hazards associated with power transmission moving parts include the drive shaft, shaft end, sprocket, pulley, chain, drive belt and gear coupling. Possible consequences include drawing-in and crushing and entanglement of a loose piece of clothing in a protruding moving part.

If a hazard is less than 2700 mm from the ground or working platform fixed barrier guards should be fitted.

### BELT

If the belt is in good condition possible consequences of contact (depending on the speed and belt characteristics) include friction burns or abrasion and impact with the belt. Install hazard controls in accordance with risk assessment results.

If the belt is not in good condition or there is evidence of a damaged belt splice, drawing-in, burns, and lacerations may be possible. Change the belt splice design or manufacturer if this is an ongoing problem. Otherwise maintain the belt and belt splice according to the manufacturer's specifications.

### UPPER AND LOWER STRANDS IN A STRAIGHT RUN

An in-running nip will be present between:

> the upper strand and the pulleys under the hopper
> the upper strand and the pulleys under the skirt-board or skirt
> the upper strand and support rollers
> the upper strand and return rollers
> the lower strand and scrapers.

The following diagrams show suggested guarding in these areas.

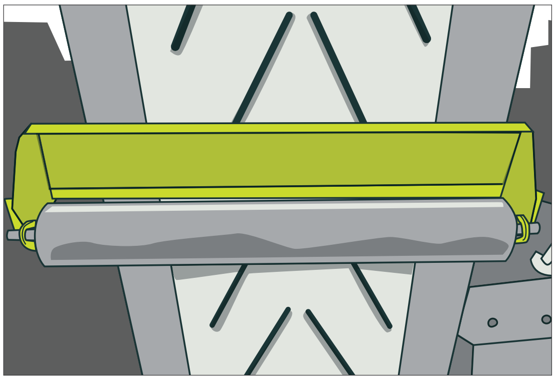


**Figure 74:** Plate type guard

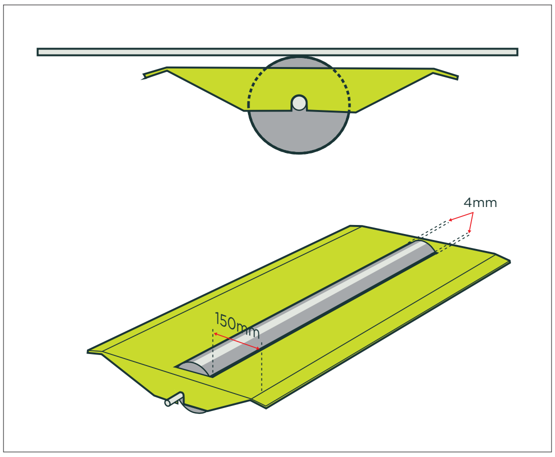



**Figure 75:** Bottom idler nip guard

### CURVED ZONE (BROW POSITIONS)

In-running nips will be present between the belt and rollers in the curved zone with a possible drawing-in consequence. Fit a fixed barrier guard and, where required, additional nip-point guards.

### HEAD AND TAIL DRUMS AND TRANSITION ZONE

In-running nips with a possible drawing-in hazard are present:

> between the belt and drums
> at the junction between two conveyors
> between the drum and fixed support brackets
> between the upper strand and the load carrying rollers in the transition zone.

Entanglement hazards also exist where the shaft is exposed. A fixed barrier guard and additional nip-point guards should be fitted.

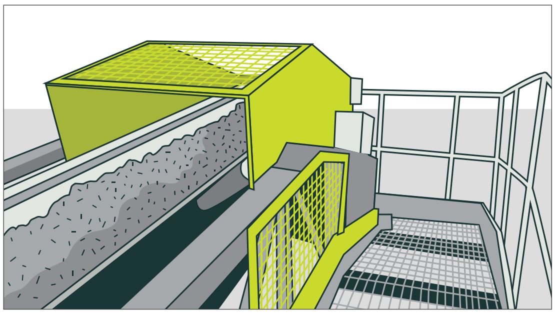


**Figure 76:** Example of head drum guards

Head drums which may become accessible by climbing stockpiles should be guarded. Alternatively stockpile heights should be strictly maintained to below 2700 mm in accordance with *AS 4024.1 Series* reach distances.

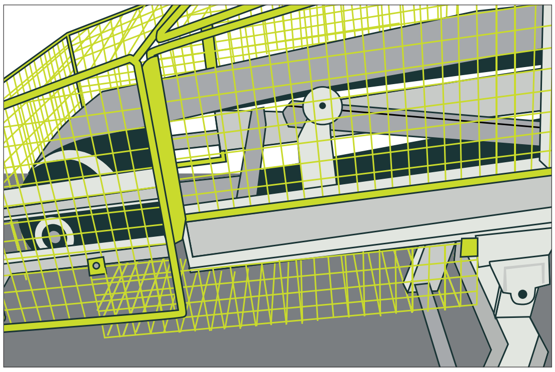


**Figure 77:** Example of tail drum guard

GRAVITY TAKE-UP UNITS

Conveyor gravity take-up units should be enclosed with mesh panels which prevent access to moving parts within the structure. This prevents the risk of the gravity take-up weight falling to ground level in the event of the belt, chains or ropes breaking. All panels should be secured so they require a tool for removal, or be interlocked.

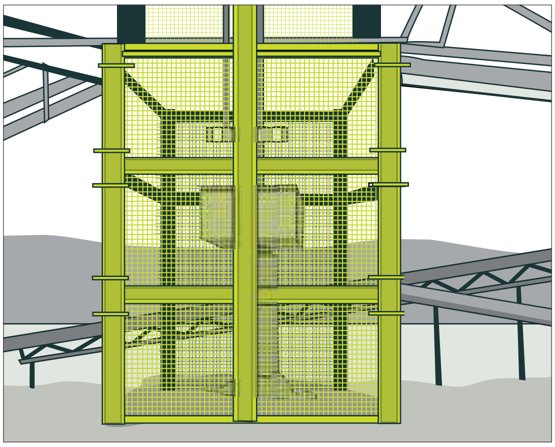


**Figure 78:** Example of perimeter guarding on gravity take-up points

FIXED OBSTACLES

Fixed obstacles which are not part of the conveyor can result in a person being trapped between the load and the fixed object. Examples of fixed objects are:

> posts
> walls
> tunnel entrances
> associated fixed equipment (ie metal detectors)
> large bulk loads (ie boulders).

In accordance with risk assessment results, consider fixed guards and deterrent devices. The objective is to keep the body, arms and legs away from the crushing area. The type of guard and its dimensions will depend on the body part at risk of being trapped and the weight of the load. The guard itself must not create a drawing-in or trapping area.

SKIRT BOARDS

You must ensure conveyors are designed, installed and used in such a way that no one is struck by falling objects[65]. The use of skirt boards can limit the amount of material that falls from conveyors (refer Figure 79).

[65] The Regulations, regulation 124 (1) (c)

Install skirt boards or other protective devices at:

> Loading and transfer areas. It is recommended that the skirt boards be at least two and a half times longer than the belt is wide, to allow the material to 'settle down'.

> Areas that have unusual features, such as magnets, crushers, and grizzlies.

> Places where people pass under the belt.

> Areas where maintenance, clean-up, or inspection activities are frequently performed.

In situations where fixed skirts are fitted above conveyor idlers, a trap point exists between the idler and the belt. Panels of guards should be fitted to prevent access to the trap points associated with the skirts of the conveyor (refer Figure 79).

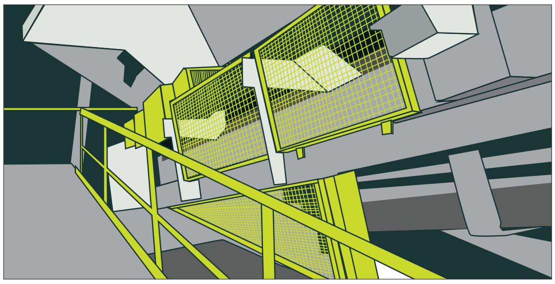


**Figure 79:** Example of skirting guards

GENERAL INFORMATION ON THE USE OF NIP GUARDS

Nip guards prevent access to the in-running nip's drawing-in zone. Where practicable, the nip guards should fill the drawing-in zone as much as possible and should be sufficiently rigid not to increase the clearance between the guard and the cylinders or the belt.

However, nip guards do not protect against the risk of pinching between the guard and the cylinder or belt, and residual risks of abrasion or burns may remain. In addition, they do not provide appropriate protection against the risks of hair or clothing being drawn in. Therefore, the risk assessment should take into account that the drawing-in effect increases with the diameter of the rollers, their roughness, their rotational velocity and the clothing or PPE worn (ie gloves).

To limit the risks of pinching, abrasion and burns, the clearance between the nip guard and the cylinder or belt should be as small as possible (maximum 4 mm). The angle between the guard and the tangent to the cylinder or between the guard and the belt should be 90° or slightly larger.

Nip guards are particularly suitable for cylinders, drums and rollers with a smooth and full end disc. They can be used with a smooth, flat or troughed belt, if they follow the profile of the belt, and the belt is tight and does not vibrate.

Where there are other machine hazards that require guarding (eg head drums with exposed rotating shafts), nip guards should be used in addition to fixed or inter-locked barrier guards.

DRAWING-IN ZONES

All in-running nips create hazardous zones (also called drawing-in zones) whose depth (p) varies with the diameter of the drums or pulleys (cylinders). The safety distance (sd) should be measured in relation to the accessible end of this drawing-in zone (called the "perimeter of the drawing-in zone") and not in relation to the axis of the cylinder.

In the case of two cylinders in contact the shape of the drawing-in zone is the angle that becomes even more acute when the cylinder radii is large. The hazardous zone is the angle between the two cylinders and is 12 mm in height.

The perimeter of drawing-in zone (p1 or p2) is determined by the 12 mm distance and the diameter of the cylinders.

In the case of a cylinder in contact with a belt, the drawing-in zone has the shape of a triangle that becomes even more acute when the cylinder radius is large. The danger zone consists of the triangle between the cylinder and the belt and is 12 mm in height.

In the case of two cylinders not in contact, or a cylinder close to a stationary object, the depth of the drawing-in zone varies in relation to:

> the diameter of the cylinders, and
> the gap between the cylinders, or
> the gap between the cylinder and the stationary object.

The depth of the drawing-in zone can then be zero ("p" = 0). The perimeter of the drawing-in zone can be confused with the axis of the cylinders if the gap is greater than 12 mm.

### IDLER ROLLER NIP HAZARDS ON HEAVY DUTY BELT CONVEYORS

There is also a significant risk of injury posed by nip-point force on heavy-duty conveyor top and bottom idler rollers and the generally increased accessibility of nip-points due to greater width of idler rollers (particularly bottom idler rollers).

The two main factors to consider when undertaking a risk assessment are:

> Degree of hazard (likely severity of injury): Determined largely by the pressure between the belt and the idler roller. For example, if the stationary conveyor belt cannot be lifted off the idler by a person using one hand, it is likely nip guards will need to be installed.
> Likelihood of access to the nip-point: Determined by the height of the nip in relation to the activities that could be performed at that location and the separating distance between the nip-point and the likely position of workers that might make contact with it.

### ADDITIONAL IN-RUNNING NIP GUARDS

From time to time access is required behind barrier guards or fixed guards, for the purpose of maintenance and cleaning of conveyor systems.

This results in potential exposure of workers to nip points. In addition guards are often left off at positions where they have to be frequently removed.

Previous initiatives have involved emergency stop cables interlinked with guards.

However, as these are not as effective as nip guards fitting directly at nip points (in addition to any other guards required) WorkSafe holds the view that these should be fitted, where practicable.

### MAINTAINING NIP GUARDS

Nip guards are essential safety devices and they must be maintained in effective working order. They should be subjected to a suitable scheme of inspection, examination and maintenance. Each nip guard should be individually identified in such a scheme to ensure its location is known, and each has its own record of inspection, examination and maintenance.

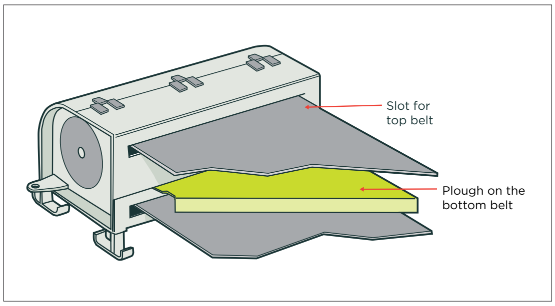



**Figure 80:** Tail drum return nip guard

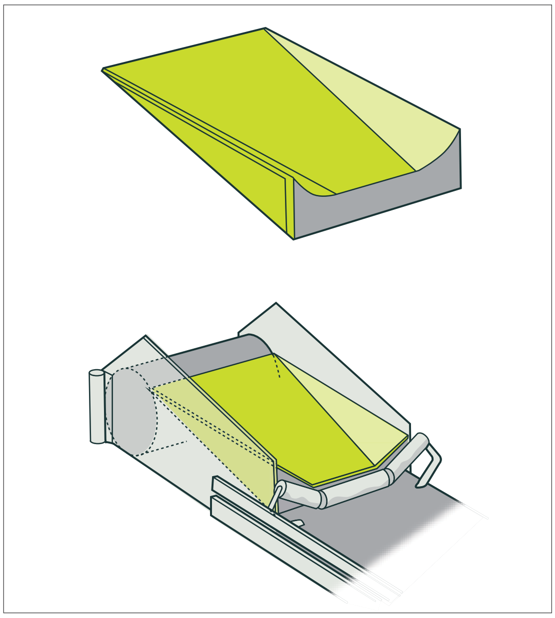


**Figure 81:** Head drum nip guard

### 12.8.2 STONE GUILLOTINE GUARDING

Stone guillotines (or stone cutters) with unguarded cutting knives can cause amputations and other serious injuries.

Examples of machine guarding methods include barrier guards, two-handed starting devices, remote-operator controls and electronic safety devices (eg light curtains). More detailed information is available from the WorkSafe *Safe Use of Machinery Fact Sheets* on the WorkSafe website.

Using machine-guarding methods that eliminate worker access to the cutting knife (called the "point of operation") is the preferred method of hazard control (refer Figure 82).

Two-handed starting devices are a cycle-initiation method that requires constant, simultaneous pressure from each hand on two separate controls to move the cutting knife. If the operator removes either hand from either of the controls, the blades will stop immediately. Two-handed starting devices are essential where fixed guards are not practicable (eg where the operator needs to feed blocks of stone into the cutting area) and operating controls are close to the knife. A suitable guard should be fitted to the side of the guillotine opposite to the controls where workers may reach into the hazardous area. Guillotines which rely on someone picking or pushing the stone after being cut should be fitted with a drop side or conveyor. This is so the stone is fed away from the hazardous area. Alternatively a suitable tool should be provided (refer Figure 83).

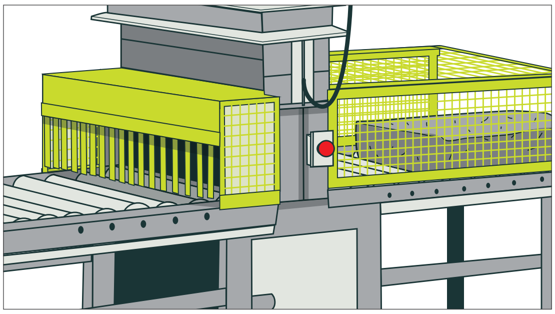


**Figure 82:** Stone guillotine with fixed guards

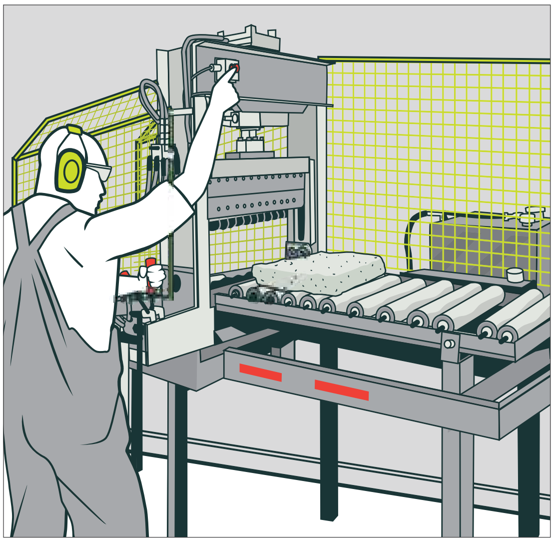


**Figure 83:** Example of two-handed starting device and drop side extraction

### 12.8.3 STONE SAW GUARDING

Stone saws range from sophisticated equipment capable of cutting large slabs of stone and intricate designs to smaller machines capable of simple cuts. Regardless of the size of the saw an operator may be in close proximity to the hazardous area when operating and suitable guarding or controls should be in place.

For larger saws the use of perimeter fences and interlocked gates would prevent inadvertent access and the operator from working in close proximity to the equipment.

Fixed guards alone might not be feasible as access is required for loading and unloading the stone. The following would all offer a high standard of protection:

> A perimeter fence and interlocked guards, such as manually-actuated sliding access gates (refer Figure 84). The interlocked guards should be fitted with a locking device so the guard remains closed and locked until any risk of injury from the hazardous machine has passed. This should allow for the rundown time of the saw blade.

> Electro-sensitive protective equipment such as light curtains at the front of the enclosure. When used in conjunction with a braking system to stop the movement before access to dangerous parts occurs. Alternatively the saw head could immediately return to a home position with a local guarding enclosure (refer Figure 85).

> Local retracting guards around the circular saw blade and pressure sensitive edges on the saw head and traversing table. This would have to be in conjunction with fast stopping times of the head and saw blade.

Guards may be extended to serve as noise enclosures. Local exhaust ventilation systems may be integral with the guard where appropriate.

Fixed guards or two-handed operator controls such as those outlined for stone guillotines may be suitable for smaller saws.

Remote-operator controls force the operator to remain at a safe distance from the hazard point (refer Figure 86). Hold-to run controls should be used for remote-operator controls. The machine should run down in the time it would take someone to reach the hazardous area when the operator removes their finger or hand from the control. Suitable controls must be in place to stop anyone else entering the hazardous area.

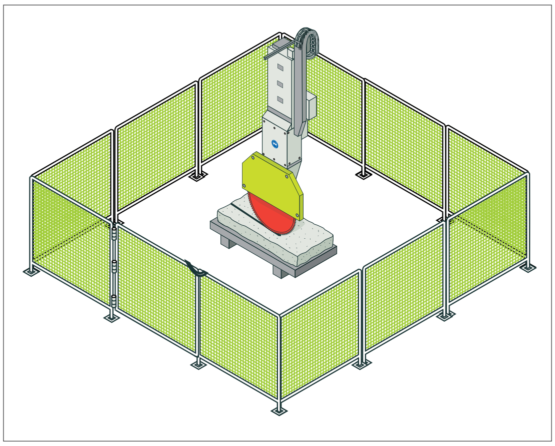


**Figure 84:** Stone saw with gate at access points

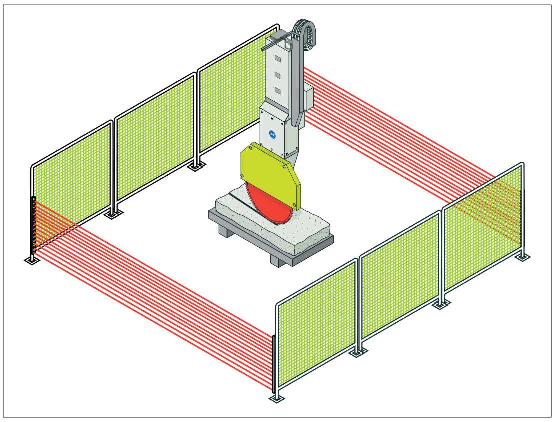


**Figure 85:** Stone saw with light curtains at access points

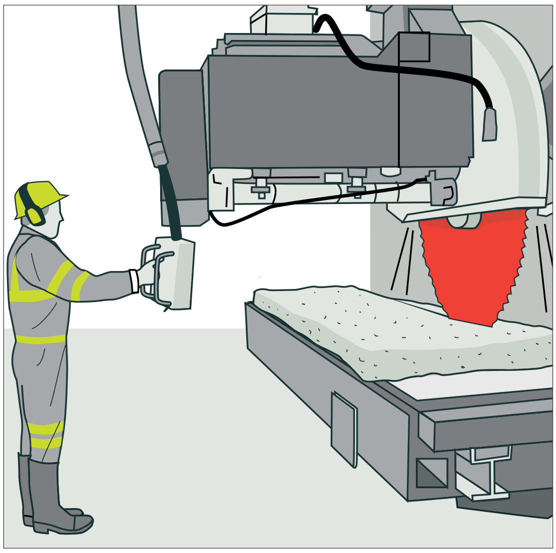


**Figure 86:** Remote operation controls on stone saw

### 12.8.4 GUARDING AND MAINTENANCE

Where maintenance requires normal guarding to be removed then additional measures will be needed to prevent danger from the mechanical, electrical and other hazards that may be exposed. This is also necessary if access is required inside existing guards. There should be clear company rules on what isolation procedures are required, and in what circumstances (eg some cleaning of mixing machinery may require isolation, even though it might not be considered a maintenance task).

Tensioning, tracking, lubrication and other maintenance is usually done while equipment is running. To eliminate the risk of injury, rods and nuts should protrude out beyond the guards. Consider grouping the lubrication points for access outside the guards (refer Figure 87).

Consider manual handling when removing guards for maintenance to be carried out. Lifting attachments on guards may be required.

For more detailed information on maintenance and repairs, including isolation and tag out, see section 17.

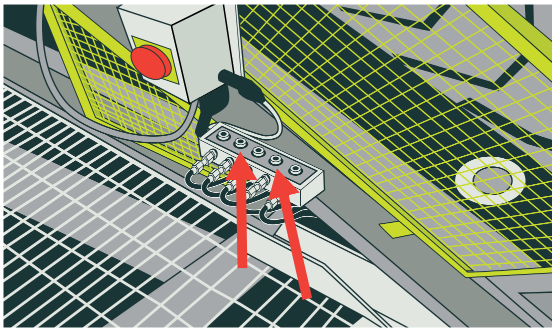


**Figure 87:** Example of remote greasing points

## 12.9 CONVEYORS

### 12.9.1 ANTI-RUN BACK DEVICE AND CONTROLLED BRAKING ON CONVEYORS

Any inclined conveyor has the potential to either run back (where the direction of the material is up) or run-away (where the direction of the material is down). These situations can be prevented by installing an anti-run back device (or sprag clutch) and controlled braking systems.

For more detailed information on anti-run back devices and controlled braking systems see *AS/NZS 4024 Safety of Machinery – Part 3610: Conveyors – General Requirements* or *AS/NZS 4024 Safety of Machinery – Part 3611: Conveyors – Belt Conveyors for Bulk Materials Handling.*

### 12.9.2 CONVEYOR CROSSOVERS AND UNDERPASSES

As well as the guarding requirements outlined in section 12.8 you must provide safe crossing points where a conveyor may be crossed[66]. Crossing over or under conveyors should be prohibited except where safe passageways are provided.

[66] The Regulations, regulation 124 (1) (d)

Access routes (as defined by the *Building Act 2004*) must maintain a minimum of 2.1 metres clearance overhead[67]. However, where people can reach into moving parts the clearance overhead should be a minimum of 2.7 metres[68] in accordance with *AS 4024.1 Series*.

**124 Conveyor belts**

(1) The mine operator must ensure that, where a conveyor belt or belts are used at the mining operation, the conveyor belt or belts are:

(c) designed, installed, and used in such a way that will protect any person near or travelling under a conveyor belt form being struck by a falling objects or objects:

(d) designed, installed, and used in such a way that will address the hazards arising from the interaction between people and the conveyor belt. This must include provision for the safe crossing of conveyor belts, where they may be crossed:

Whenever conveyors pass adjacent to, or over, work areas, roadways or other passageways, protective guards should be installed. The guards should be designed to catch and hold any load or material that may fall off or become dislodged from the conveyor (for more information on conveyor skirt boards see 12.8.1).

Where conveyors are operated in tunnels, pits and similar enclosures, ample room should be provided to allow safe access and operating space for all workers.

#### 12.9.3 PRE-START WARNINGS ON CONVEYOR BELTS

Pre-start warnings must be provided on conveyor belts to address any hazard when they are started[69].

On overland conveyor systems, the devices should be placed at the transfer, loading, and discharge points and those points where workers are normally stationed. Warning signs stating “conveyor may start without warning” should be strategically placed along overland conveyors where it is reasonably foreseeable that people may gain access.

For more information on pre-start warning systems see section 12.11.

#### 12.9.4 RECLAIM TUNNELS

The nature of reclaim tunnel operations means the presence of people in the tunnel is normally only required on an infrequent and irregular basis. Loading operations are usually remotely activated and control room operators may not expect workers to be in the reclaim tunnel which can lead to hazardous situations. Workers should only enter the reclaim tunnel to inspect, clean or maintain the system when effective safe systems of work are in place.

Reclaim tunnels may be a confined space entry (see section 16.1.4).

### 12.10 EMERGENCY STOPS

Emergency stops, including pull wire emergency stops, should not be used as a substitute for guards. They are only a backup for other control measures. Emergency stops should be in red with a yellow background where practical and signs should be erected for easy identification (refer Figure 88).

[67] Compliance Document for NZ Building Code – Clause D1: Access Routes
[68] AS/NZS 4024.3610 C2.1 (currently draft)
[69] The Regulations, regulation 124 (1) (a)

Do not use emergency stops to lock-out the plant or equipment because the actuators can separate from the contacts. If this happens, the control will show the plant is off but it is actually on.

Emergency stops should:

- be prominent and clearly and durably marked
- be immediately accessible to each user of the plant or equipment
- have red handles, bars, push buttons or pull cords (labels can also be used)
- not be affected by electrical or electronic circuit failure.

Mine operators must fit an emergency stop system that can be activated at any accessible point along the length of a conveyor belt[70].

For more detailed information on emergency stop controls see the WorkSafe *Best Practice Guidelines for the Safe Use of Machinery* and *AS/NZS 4024 Safety of Machinery: Part 1604: Design of controls, interlocks and guarding – Emergency stop – Principles for design.*


**Figure 88:** Emergency stop with signage (photo courtesy of Fulton Hogan Miner Rd Quarry and NZ Steel Taharoa)

## 12.11 PRE-START WARNING SYSTEMS

Pre-start warning systems should be provided on machinery where sudden, unexpected operation could cause serious or fatal injuries to those who may be close to the machinery.

Because mines and quarry processing areas can be noisy and spread out it will normally be appropriate to provide both visual and acoustic prestart warnings that work in conjunction with one another.

[70] The Regulations, regulation 124 (1) (b)

Acoustic signals should:

> sound for long enough before the plant or equipment starts to provide adequate warning to anyone who may be in a position of risk

> loud enough so they can be heard in the area they are providing a warning for

> be at a level higher than the ambient noise without being excessive or painful

> be clearly different from any other warning signals or alarms.

Visual signals (eg flashing lights) should be placed so people close to the plant or equipment will have the best opportunity to see it. You may need multiple visual signals depending on the set-up of your plant and whether or not an acoustic signal will be sufficient to provide warning. Where visual signals are used they should be of a suitable brightness and colour contrast to the background.

For more detailed information on acoustic and visual signals see *AS/NZS 4024 Part 1904: Design, controls, actuators and signals – Indication, marking and actuation – Requirements for visual, auditory and tactile signals.*

## 12.12 ELECTRICITY

The *Electricity (Safety) Regulations 2010*:

> state the generic rules and requirements about electrical safety, and what is deemed to be electrically safe and unsafe

> deal with the design, construction and use of works, installations, fittings and appliances

> provide for installations to be designed and installed under *AS/NZS 3007 Electrical equipment in mines and quarries – Surface installations and associated processing plant*

> define certification and documentation required for all electrical works

> set out in schedules all of the applicable Standards, with a focus on the adoption of international Standards

> define requirements relating to safety management systems (SMSs)

> provide for offences including infringement offences.

The amendments to the *Electricity (Safety) Regulations 2010* in December 2013 complement the Regulations. They improve design requirements, periodic assessment and verification of safety requirements, specific requirements relating to Prescribed Electrical Work (PEW), design, maintenance and day to day operations.

It is important any electricians you use to perform electrical work are familiar with the *Electricity (Safety) Regulations 2010* and they certify all work they perform. One particularly important document is *AS/NZS 3007:2013 Electrical equipment in mines and quarries – Surface installations and associated processing plant*. Make sure all electricians are familiar with this Standard.

Mobile and relocatable equipment at alluvial mines and quarries must be assessed yearly against AS/NZS 3007 by a qualified mining electrical inspector[71].

Machinery must be properly grounded before use and all connections, switches and cables must conform to the *Electricity (Safety) Regulations 2010*.

As a general rule:

(a) Use Residual Current Devices (RCD's).

(b) Electrical substations should be kept clean and not used as stores. They should be kept locked with access to authorised workers only.

(c) All equipment should be part of the electrical maintenance and inspection scheme.

(d) Batteries should be treated with caution. Manufacturer's instructions should be followed for maintenance and precautions to be taken (ie PPE).

[71] *Electrical (Safety) Regulations 2010*, regulation 78D

(e) Dust accumulations can have a serious effect on the safe functioning of electrical equipment. Make sure housekeeping procedures are in place.

(f) All electrically powered equipment should be capable of being isolated. The isolation points should be clearly labelled and means of isolation provided (see section 17.2).

(g) Where the operators have been properly trained it may be appropriate to access some electrical equipment for the purposes of resetting trips. In these cases it may be permissible to open cabinet doors provided the equipment inside is properly shrouded to prevent inadvertent access or arc flash.

(h) Switchboards should be securely locked at all times. Where wiring is damaged it should be reported immediately. Water should not be allowed to accumulate in switch boards or switch rooms.

(i) Underground cables and pipes should be accurately located on a site plan and identified before digging.

For more detailed information on safety around underground cables and pipes see the WorkSafe *Approved Code of Practice for Excavations for Shafts and Foundations.*

### 12.12.1 FLEXIBLE CORDS

Flexible cords must have a current tag issued in accordance with *AS/NZS 3760 In-service safety inspection and testing of electrical equipment*[72].

A flexible cable or cord (for supply purposes) is one that has one end connected to a plug with pins designed to engage with a socket outlet, and the other end either:

> connected to terminals within the equipment, or

> fitted with a connector designed to engage with an appliance inlet fitted to the equipment.

Flexible cords are prone to damage because they are often outdoors in operational areas and can be subject to falling material, repetitive use, movement, vibration and extremes of weather. Regardless of the date of the tag all flexible cords should be examined before being plugged in and used. Consider any shock or tingle as a warning of a potential safety problem. If this occurs immediately switch off, isolate and remove the cable and do not be use it again until tested by a competent electrician.

**Figure 89:** Flexible cords with tags

### 12.12.2 TRAILING CABLES

Safe systems of working with trailing cables should include meeting the New Zealand *Electricity (Safety) Regulations 2010* and *AS/NZS 3007 Electrical equipment in mines and quarries – Surface installations and associated processing plant.*

These safe systems of working with trailing cables should also include:

> Regular inspections including in-situ visual inspection by machine operators and regular documented safety assessments (at least annually).

[72] *Electricity (Safety) Regulations 2010*, regulation 26

> Route criteria including support measures (where applicable), methods and heights for crossings, location of cables in proximity to roadways, protection measures required where it is necessary for vehicle crossings and so on.
> Methods for relocation of cables and provision of adequate equipment to perform the task such as cable reelers or relocators.
> Defined methods for manual handling and provision of adequate mechanical lifting aids to eliminate manual handling sprains and strains. Equipment to separate and join plugs should be sought.
> Regular inspection, maintenance and testing performed on substation earth systems including earth mats, earth impedance and earth connection points, protection relays and trip batteries.
> Provision of unique clear identifiers for each cable and trailing cable plug and substation outlet.
> Defined standards for the circumstances under which trailing cable protection relays can be reset and power re-energised onto a cable where the relay has indicated a fault to be present.
> Developing, implementing, monitoring and reviewed systems of high voltage switching, access and authorisation.
> Minimising direct handling of energised cables. Anyone required to directly handle energised trailing cables should wear insulating gloves covered by leather outer.

Training should be provided in the above and in trailing cable hazard awareness for all people required to work with them. Workers associated with relevant tasks should be consulted in relation to the development of the systems and standards mentioned above.

## 12.13 CRANES AND LIFTING EQUIPMENT

Where there is a crane on site, you must comply with the *HSE (Pressure Equipment, Cranes and Passenger Ropeways) Regulations 1999* and should comply with the *Approved Code of Practice for Cranes*. Fixed cranes includes gantry cranes, overhead hoists, monorail systems, davit arms or fixed lifting points. The structures supporting the crane must be certified by a chartered professional engineer with respect to design, construction and non-destructive testing, as relevant.

The structure certificate issued must specify:

(1) design standards referenced

(2) maximum permissible safe working load and any load limitations or conditions

(3) details of equipment that may be used on the certified structure[73].

Items of mobile plant, not originally designed as a crane used for load-lifting incidental to their principal function are exempt from the *Health and Safety in Employment (Pressure Equipment, Cranes, and Passenger Ropeways) Regulations 1999*. This is subject to the following conditions as applicable:

(1) Lifting points and equipment used for rigging loads are to be certified by a Chartered Professional Engineer; and

(2) In the case of hydraulic excavators with an operating weight of 12 tonne or more the following additional conditions apply:

   (a) The equipment is not to be modified to make it operate as a crane other than the provision of a lifting point; and

   (b) Hose burst protection valves are required; and

[73] **Note:** Some equipment is exempt from this requirement. Refer to *Notice of Exemption for Equipment under the Health and Safety in Employment (Pressure Equipment, Cranes, and Passenger Ropeways) Regulations 1999, New Zealand Gazette, No 188, page 4517, 17 December 2009*

(c) Operators and ground support personnel are to be adequately trained as required by section 13 of the *HSE Act*; and

(d) Operations are to be carried out in accordance with the *Approved Code of Practice for Load-lifting – Rigging*; and

(e) The equipment is to have a loading chart available to operators[74].

All sites should develop a safe system of work for the use and management of all lifting equipment in accordance with the WorkSafe *Approved Code for Practice for Load-lifting Rigging*. This includes but is not limited to:

> Every lifting appliance and item of loose gear shall be clearly and permanently marked with its WLL by stamping, or where this is impracticable or not recommended, by other suitable means. Also, a unique identifying numbering system to clearly identify individual items should be used.

> Visual inspection prior to and after use.

> Examination by a competent person regularly depending on frequency, use, and environmental conditions but not exceeding 12 months.

> A register should be kept for lifting equipment. The register should show the date of the last recorded examination or test, and any alterations.

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[74] *Notice of Exemption for Equipment under the Health and Safety in Employment (Pressure Equipment, Cranes, and Passenger Ropeways) Regulations 1999, New Zealand Gazette, No. 61, page 1784, 3 June 2010*

PART D

# 13/

## WORKER FACILITIES

### IN THIS SECTION:


13.1 Washing facilities

13.2 Toilets

13.3 Drinking water

13.4 Facilities for employees who become ill at work

13.5 Facilities for changing and storing clothes

13.6 Facilities for meals

**You must provide suitable and sufficient numbers of facilities to make sure the health and safety of everyone at the site. Facilities are those that are necessary for the well-being of your workers, such as washing, toilet, rest and changing facilities, and somewhere clean to eat and drink during breaks.**

Keep all facilities in a clean and sanitary condition.

Facilities must comply with the *Building Act 2004*, *Building Code, Health and Safety in Employment Regulations 1995* and local authority bylaws as appropriate.

For more detailed information on facilities see:

> WorkSafe *Guidelines for the Provision of Facilities and General Safety in Commercial and Industrial Premises*.

> *Guidelines for the Provision of Facilities and General Safety in Forestry Work*.

## 13.1 WASHING FACILITIES

Cold water, cleansing agents and suitable hand drying facilities must be provided at all work sites[75].

Where chemicals are being handled, mixed or applied, showers or suitable cleaning agents may be needed. Additional emergency showers may also be required (refer to the safety data sheet).

## 13.2 TOILETS

Toilets must be provided in accordance with the *Building Act 2004, Building Code* and *Health and Safety in Employment Regulations 1995.*

Facilities should be as near as practicable to the work, but may be off-site if transport is provided. Facilities should not be so remote as to discourage their use by workers.

Toilets must be kept clean and tidy, and be convenient to workers[76].

## 13.3 DRINKING WATER

An adequate supply of wholesome drinking water[77] must be readily available, and should be clearly labelled as drinking water. A common drinking container should not be used. Containers for drinking water should be kept clean and protected from contamination.

## 13.4 FACILITIES FOR EMPLOYEES WHO BECOME ILL AT WORK

Rest facilities, or if necessary, transport to home or medical assistance for employees who become ill at the place of work must be provided[78].

[75] *Health and Safety in Employment Regulations 1995*, regulation 4 (2) (b)
[76] *Health and Safety in Employment Regulations 1995*, regulations 4 (1), 4 (2) (a) and 9
[77] *Health and Safety in Employment Regulations 1995*, regulation 8
[78] *Health and Safety in Employment Regulations 1995*, regulation 6

## 13.5 FACILITIES FOR CHANGING AND STORING CLOTHES

You must provide an area where workers can change, in privacy, clothes that become wet or contaminated at work[79]. Adequate clean space should be provided so workers can store clothes not used at work where appropriate.

## 13.6 FACILITIES FOR MEALS

You must provide facilities for workers to have meals and rest periods in reasonable comfort and sheltered from the weather[80]. Any facility used for shelter and meal purposes must not be used for the storage of tools, materials or petroleum products.

Suitable rubbish disposing facilities should also be available.

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[79] *Health and Safety in Employment Regulations 1995*, regulations 5 (2) (b) and 5 (2) (c)

[80] *Health and Safety in Employment Regulations 1995,* regulation 4 (2) (k)

PART D

# 14/

# SITE SECURITY AND PUBLIC SAFETY

IN THIS SECTION:

14.1 Access to sites

14.2 Barriers

14.3 Signage

**You must consider ways in which working the site may create a risk not only to workers but to the public.**

This section describes how to manage site access and other areas that may pose a danger to the public.

From a health and safety perspective, it is good practice to divert public rights of way around mines or quarries. Where it is not possible, precautions should be implemented, based on a detailed risk assessment of the route and the area around the site. The precautions should be reviewed regularly.

## 14.1 ACCESS TO SITES

Access to sites should be controlled to make sure unauthorised persons cannot travel to a location where they may be at risk from site operations[81]. This is particularly important for sites where there are sales to the public or in residential areas. Control measures may include signage, automated barrier arms or worker controlled areas (eg a weighbridge operator).

## 14.2 BARRIERS

Providing and maintaining suitable barriers around the site to discourage trespass may be appropriate. Trespass means entry to the site without express or implied permission.

Barriers are appropriate where it is reasonably foreseeable that members of the public, including children, are likely to trespass on the site, and could suffer injury if they did so.

The type of barrier required depends on the risks. In a rural area, where risk of public access is low, hedges, trenches and mounds may be enough. In areas where there is evidence of persistent trespass which places them at significant risk, substantial fences may be required.

Workers should be encouraged to report cases of trespass or evidence that people have been on the site. They should also be told what action to take if they discover trespassers.

## 14.3 SIGNAGE

Suitable signs warning people of the possible hazards at the site should be erected at entry points and, where necessary, along boundaries (refer Figure 90 and Figure 91). Any signs should be maintained in a legible condition.

[81] *HSE Act,* sections 15 and 16


**Figure 90:** Examples of signage warning of hazards


**Figure 91:** Example of sign at gate

PART D

# 15/

# WORKER HEALTH

## IN THIS SECTION:


15.1 Worker health principal hazards and control plan
15.2 Worker health monitoring
15.3 Noise
15.4 Vibration
15.5 Breathable hazards
15.6 Working in extremes of temperature
15.7 Manual handling and lifting
15.8 Hours of work and fatigue
15.9 Psychosocial hazards
15.10 Ultraviolet radiation
15.11 Contaminated land
15.12 Hazardous substances
15.13 Drugs and alcohol
15.14 Personal protective equipment (PPE)

**Managing the health and wellbeing of your workers is an important part of being a good employer. It also pays dividends in terms of increased productivity, reduced sick leave, improved staff morale, and loyalty.**

This section describes how to:

> identify and manage risks to workers' long-term health

> monitor workers' health

> protect workers from specific hazards including vibration, dust, fumes, ultraviolet radiation, and chemical or biological hazards

> help workers handle the physical and mental pressures of work safely

> provide appropriate personal protective equipment (PPE).

Ineffective workplace health hazard management is responsible for significantly higher levels of injury and death than workplace accidents. Within the context of occupational health, effective management is achieved by ensuring relevant health hazards are identified and, as a key objective, eliminated at source. It is only appropriate to control health hazards by reducing the likelihood of harm when elimination is not practicable. Personal Protective Equipment (PPE) is the lowest form of control and should be a last resort.

For controls to be effective, managers, workers and their representatives should:

> have easily accessible information on the nature of a health hazard and how it can be controlled and monitored. This information must be updated as knowledge on new health hazards becomes known, and new techniques for managing them are developed

> have the necessary capability – both through access to equipment and technology, and the managerial skills to make sure good systems are in place

> be motivated to take action to control exposures to health hazards and reduce risk.

## 15.1 WORKER HEALTH PRINCIPAL HAZARDS AND CONTROL PLAN

To determine whether there are principal hazards that may have long-term effects on mine workers' health, it is necessary to consider situations workers may be exposed including, but not limited to:

> the materials, substances or fumes workers may be exposed to, and the likely consequences of any such exposure (ie coal dust, silica dust, diesel particulates, welding fumes, chemicals and so on)

> the type of tasks undertaken (eg work outdoors, working in extremes of temperature, manual handling), and the place in which they are undertaken

> the equipment or tools being used and how workers interact with them (eg noise and vibration)

> the length of time workers may be exposed to any potentially hazardous material, fumes, substances or situations

> the hours of work (including travel time to and from sites, and shift work), sleep disruption, sleep deprivation and individual workload

> the influence drugs or alcohol may have on a worker.

You cannot accurately assess the risk of some hazards without undertaking scientific testing or measurement by a competent person. This includes checking that relevant exposure standards are not being exceeded (eg by using noise meters to measure noise levels, and dust deposition meters to measure airborne dust). Extractive sites should undertake workplace and individual monitoring for the following hazards:

> dust (including diesel particulates)
> noise
> vibration
> welding fumes and gases (where applicable).

If the degree of hazard or risk is not clear, the advice of an occupational health, occupational hygiene or occupational medical specialist should be sought.

If there are principal hazards relating to worker health at a mining operation, the SSE must ensure there is a principal control plan for the mining operation. This must comply with regulations 107 and 108 of the Regulations.

The worker health control plan must contain information detailed in regulation 108 of the Regulations. In summary, the worker health control plan must address how the following hazards will be monitored and controlled:

> noise and vibration
> dust, diesel particulates and fumes
> working in extremes temperatures and humidity
> changes in atmospheric pressure
> manual handling and lifting
> hours of work, and fatigue
> psychosocial hazards (stress, bullying and violence)
> ultraviolet and ionising radiation
> biological hazards
> any other hazard that may adversely affect the health of workers.

The worker health control plan must also set out:

> development of strategies to deal with the consumption of drugs or alcohol
> a process for obtaining urgent medical treatment for mine workers where required.

The worker health control plan should be developed in the context of the whole health and safety management system, and not in isolation from other plans, processes and procedures that rely on the control plan. This will ensure gaps and overlaps in information and procedures are identified and used in the implementation of suitable controls to minimise the likelihood and potential risks and impacts.

## 15.2 WORKER HEALTH MONITORING

When using minimisation hazard controls, you must monitor employees' exposure to the hazard (work environment monitoring) and, with employees' informed consent, monitor their health in relation to the hazard[82].

To make sure personal health information is kept private; manage disclosure of health monitoring information. Typically, the occupational health practitioner will provide a summary of health monitoring results that do not identify or disclose any individual. These summarised results can be used to determine whether health hazard controls are achieving the desired level of protection.

Offer and pay for medical examinations to each worker at the following times:

1. immediately before the worker starts work (pre-employment medical)

[82] *HSE Act,* section 10(2)(e)

2. immediately before the worker stops working at the site if their last medical is more than 12 months old (exit medical)
3. periodically throughout their employment and no less than every 5 years (usually done annually but this is dependent on medical practitioner advice)[83].

Consult with workers before choosing a medical practitioner or nurse to carry out the health monitoring (or medicals). Health monitoring must establish the level of health of workers as it relates to the work they are carrying out at the time[84].

You must make records of health monitoring available to WorkSafe on request. Such records must not identify or disclose any individual unless first obtaining the workers consent[85].

Records of health monitoring must be kept:

> for at least 30 years after the monitoring took place in the case of any hazard that is known to have a cumulative or delayed effect (ie noise induced hearing loss or respirable dust exposure)

> for at least 7 years after the monitoring took place or until the worker stops working at the site, whichever is the later In the case of all other hazards.

## 15.3 NOISE

You must take all practicable steps to ensure workers are not exposed to noise levels above 85 dB(A) $L_{Aeq,8h}$ and a peak noise level of 140 dB $L_{peak}$. This is regardless of whether they are wearing a personal hearing protection device.

The 85 dB(A) exposure limit is based on an 8-hour working day, it is highly likely extractive operations will need to take into account extended shifts in any noise assessment. This is due to the longer period of time a person is exposed to potentially hazardous noise, and the shorter time the person's ears have to recover before noise exposure resumes. Situations may also exist when the longer exposure time is a key factor in noise exposure exceeding the exposure limits.

Much can be achieved by careful design and maintenance of equipment and possibly by changing work practices.

Methods for reducing exposure include:

(a) using low noise machinery many extractive sites equipped with modern machinery and vehicles achieve noise exposures below workplace exposure standards
(b) reducing sound radiating surfaces (eg using mesh guards instead of plate metal)
(c) vibration isolation (eg operators' cabins and vehicle cabs)
(d) using sound absorbing linings (eg in vehicle cabs and engine cover linings)
(e) using exhaust silencers (eg on pneumatic drill rigs and vehicle engines)
(f) using enclosures around equipment (eg to control noise in workshops)
(g) using noise refuges for workers (eg a cabin at the control console of crushing and screening equipment)
(h) maintenance (eg replace defective silencers and repair broken windows in vehicle cabs).

Such measures may be used alone or in combination. The list is not exhaustive and other techniques may be applicable. Many effective solutions are low cost.

Personal protective equipment (PPE) (ear protectors) should only be used as an interim solution. It may be used long-term when all other reasonably practicable measures have been taken but have not, in themselves, achieved adequate noise reduction. Reducing noise exposure is the main objective.

[83] The Regulations, regulation 128(1)
[84] The Regulations, regulation 128(2)
[85] The Regulations, regulation 128(4)(a)

For more detailed information on noise control methods see the WorkSafe *Approved Code of Practice for the Management of Noise in the Workplace*. This includes information on workplace exposure standards, work environment monitoring, health monitoring and personal protective equipment (PPE).

## 15.4 VIBRATION

There are two types of vibration which may cause harm to workers. Whole body vibration (WBV) and hand-arm vibration (HAV).

WBV is the vibration and shock you feel when you sit or stand on a vehicle or machine travelling over rough ground or along a road. It can also be the vibration when you work near powerful machinery such as a rock crusher. Shocks can occur, for example, when driving over bumps or potholes.

Exposure to WBV at low levels is unlikely on its own to cause injury, but it can aggravate existing back injuries which may cause pain. Effects of long-term exposure to WBV include:

> disorders of the joint and muscle disorders, especially the spine
> cardiovascular, respiratory, endocrine and metabolic changes
> digestive system problems
> reproductive damage in women
> vision or balance impairment
> discomfort and interference with activities.

HAV is the vibration and shock transmitted to your hands and arms when using handheld powered tools or equipment which vibrates while in operation.

HAV can cause hand-arm vibration syndrome (HAVS) and carpal tunnel syndrome (CTS) which can be debilitating. The risk of developing HAVS or CTS depends on the length of time a person is exposed for and the magnitude of the vibration.

You can reduce and control vibration exposure by:

> maintaining plant, equipment and vehicles
> reducing speed
> designing and constructing machinery and vehicles to lessen vibration emission
> maintaining roadways and other vehicle operating areas
> purchasing or replacing hand-held tools with ones with less vibration emission
> purchasing or replacing machinery or vehicles with ones with less vibration emission
> reducing time spent using hand-held tools or driving
> organising work and designing workstations to avoid uncomfortable postures and the need for high manual effort to grip, push or pull equipment
> providing personal protective equipment (eg gloves).

## 15.5 BREATHABLE HAZARDS

### 15.5.1 RESPIRABLE DUST

One of the health risks from working at an extractive site is the exposure to fine dust, containing particles that may lead to chronic and possibly fatal lung disease. Respirable dust does not have to be visible or irritating to seriously impact on health.

Workers may be exposed to fine dust from:

**Hand-operated drills** used mainly for drilling small diameter holes in monumental stone quarrying these can be used for explosives, plug and feathers or hydraulic splitters.

**Drilling rigs** used mainly for drilling holes for blasting, exploration or ground support.

**Crushing or milling**: Compressive-type crushers produce dust but do not themselves induce excessive air movement, although moving materials do and dust, either from the materials or the actual crushing process, becomes airborne. Impact-type crushing machines involve a rotating part which acts as a fan and generates considerable air movement. With this type of high-reduction crushing, considerable quantities of airborne dust are generated.

**Screens** used to extract or reject specific-sized material from the feed product. Screening equipment creates dust by degradation, and the action also affects the release of dust in the material.

**Conveyors, feeders and loading** used to transfer product from one position to another. Dust is released from the transfer points and can be aggravated if not enclosed and protected from wind.

**Heating or drying** of rock fragments inevitably causes large emissions of airborne dust, unless exhaust gases are fully treated.

**Bagging** dry materials, particularly powders, and bag damage. Bagging products while damp does not present any dust problems.

**Portable hand-operated saws** generally used in monumental stone and slate quarries for the cutting of stone and for the creation of slits so wedges can be used for splitting.

**Static saws**: a wide range of saw types are used for cutting blocks or stone and slate into selected sizes. Most saw blades are diamond tipped and use water for cooling. The water also acts as dust suppression.

**Splitting or dressing** takes place at monumental stone and slate quarrying operations. Some splitting involves drilling small diameter holes and using plug and feathers, or hydraulic splitters. Using chisels for splitting and dressing of slate creates dust in the replacing operator’s breathing zone and the hand dressing of stone (masonry work) also creates dust emissions.

**Traffic** on haul roads kicking up dust into the air. Fully enclosed cabs and watering of haul roads can help control this hazard.

**Other activities** including stacking, cleaning (especially when using brooms) and driving are a source of dust. You may need to assess personal dust exposure during these activities.

Hazard controls must include reduction at source. For example:

> dust collectors on drills and dust suppression sprays and other dust collection equipment

> water applied directly to the drill tip and water supply to saws

> screen hoods

> encapsulation

> extraction systems

> integral units

> stockpile dampening.

Control measures must be maintained in an effective state, in efficient working order and in good repair. Where engineering controls are implemented, thorough examinations and tests should be carried out regularly.

### 15.5.2 DIESEL PARTICULATES

In 2012 the International Agency for Research on Cancer (IARC) found sufficient evidence to conclude diesel engine exhaust is carcinogenic to humans. The physical properties of diesel engine exhaust means it can accumulate in an enclosed space where there is insufficient rate or quality of ventilating air.

Most extractive sites are likely to use diesel engines. Workers near diesel powered equipment may be exposed to diesel emissions or diesel particulate matter. Confined spaces, workshops or when working in deep pits where temperature inversions can cause exhaust fumes to be trapped in the pit are particularly at risk.

To be successful in reducing and controlling the hazards associated with diesel engine exhaust a 'whole of site' approach is required. This will require co-ordination of expertise and a high level of process discipline in many functions including:

> management
> maintenance
> engineering and ventilation
> training
> supply and procurement.

Engineering controls are the most effective strategy for reducing the exposure to diesel emissions and diesel particulate matter. Administration controls, including changes to the way work tasks are performed and personal protective equipment may also be required.

### 15.5.3 WELDING AND GAS CUTTING FUMES

Welding fumes are a complex mixture of metallic oxides, silicates and fluorides. Fumes are formed when a metal is heated above its boiling point and its vapours condense into very fine particles (solid particulates).

Welding gases are gases used or produced during the welding and cutting processes. Examples are shielding gases, gases produced by the decomposition of fluxes, from the interaction of ultraviolet light, high temperatures with gases or vapours in the air.

Exposure to welding gases and fumes can be fatal. You cannot rely on the sense of smell to detect any of these hazards. Some cannot be smelt at all and the sense of smell can become insensitive to those odours it can detect.

Further information on welding hazards is outlined in section 16.1.5.

For more detailed information on welding safety, including methods of fume control, see the WorkSafe guidance *Health and Safety in Welding.*

### 15.5.4 LEGIONNAIRE'S DISEASE

Legionnaire's disease (legionellosis) is a type of pneumonia caused by the legionella bacteria which may be found in water systems. Infection is caused by inhaling fine water droplets containing the viable bacteria. There is no evidence to suggest that mining and quarrying present a heightened risk of exposure to legionella compared to other industries. However, large quantities of water can be used at extractive sites for dust suppression and processing.

Risk factors include water, growth temperature range of 20°C to 45°C, nutrients (ie biofilm or algae, rust and scale) and aerosol, spray or mist. Mines and quarry water supplies typically use non-mains supply sourced from bore holes or lagoons. It is usually recycled and prone to contamination by process dust and environmental material such as soil and plant material. Stored water in tanks or pipes maybe stagnant for periods and in warm weather the temperature may rise above 20°C.

The following water systems are likely to include the risk factors described above. However, this list is not exhaustive:

> water being sprayed on to material by fogging cannons or directional misting units
> water being sprayed on to materials for wet suppression of dust at transfer or discharge points
> water being sprayed on to roads for wet suppression of dust using water bowsers or fixed sprays
> use of hoses to clean areas of hard standing around processing plant and site buildings
> water spray from vehicles or wheel washers
> use of water as part of the production process such as barrel washers, wet scrubbers, and cooling of cutting blades on saws

- water curtains for dust control such as for dimensional stone cutting and processing
- emergency showers.

Appropriate control methods should focus on limiting the conditions that encourage growth. By applying simple, low cost measures the potential for growth and thereby the potential for exposure can be significantly reduced and appropriately controlled.

## 15.6 WORKING IN EXTREME TEMPERATURES

Working in very cold and very hot temperatures can be hazardous to a person's health. Excessive exposure to heat is referred to as heat stress and excessive exposure to cold is referred to as cold stress.

In a very hot environment, the most serious issue is heat stroke which can be fatal. Heat exhaustion and fainting (syncope) are less serious and can affect a person's ability to work.

In very cold temperatures, the most serious issue is hypothermia (or dangerous overcooling of the body) which can be fatal. Another serious effect of cold exposure is frostbite or freezing of the exposed extremities such as fingers, toes, nose and ear lobes.

Victims of heat stroke and hypothermia are unable to notice the symptoms, so their survival depends on co-workers' ability to identify symptoms and seek immediate medical help.

Where workers are, or could be, required to work in extreme temperatures you must implement controls to eliminate or minimise the risks.

For more detailed information on working in extremes of temperature see WorkSafe's *Guidelines for the Management of Work in Extremes of Temperature.*

## 15.7 MANUAL HANDLING AND LIFTING

Manual handling can result in serious back injuries, musculoskeletal disorders, acute injuries (eg sprains and strains) and injuries sustained through slips, trips and falls.

Assess the manual handling tasks undertaken at your site and determine whether they are necessary. If they are, and you cannot eliminate manual handling by providing suitable lifting equipment, then you should make the task as easy as possible for everyone involved and reduce the time people are required to do it.

For many manual handling tasks there may be a number of control options that appear feasible. Some of the control options may need to be trialled and evaluated before they are finally implemented (to identify whether they are appropriate for that particular work system). This trialling can be relatively quick and informal, or may need to be formal and extensive, to get the best solution possible.

## 15.8 HOURS OF WORK AND FATIGUE

Fatigue is a physical and mental state caused by a range of influences. It reduces a person's capabilities to an extent that may impair their strength, speed, reaction time, coordination, decision making or balance.

A level of fatigue is a natural response to the mental and physical effort of everything we do. Normally, good quality sleep reverses the imbalance, allowing the body and the brain to recover. However, long working hours, working with intense mental or physical effort, or working during some or all of the natural time for sleep can all cause excessive fatigue.

Workers may work extended hours for long periods of time. Night shifts are also possible as are strenuous physical activities. Travelling to and from the worksite can add hours to the working day, as sites can be in remote locations.

Preventing fatigue begins with careful planning of tasks and their scheduling. Tasks should be designed so extreme exertion (mental and physical) are avoided and there is sufficient recovery time available.

Working hours should be agreed which provide all workers adequate opportunity to manage fatigue, including:

> regular rest breaks
> meal breaks
> a daily or nightly sleep period
> shared driver responsibilities.

Meal and rest breaks for employees must, at a minimum, comply with Part 6D of the *Employment Relations Act 2000*.

## 15.9 PSYCHOSOCIAL HAZARDS

Psychosocial hazards for the purposes of this guidance include stress, bullying and violence. Stress can be a reaction to bullying and violence. Violence may also result in physical harm.

Violence is a hazard that may be encountered at work. It can occur suddenly, without notice or provocation. It may cause mental and physical pain and suffering and may result in permanent disability or even death.

Bullying affects people physically and mentally, resulting in increased stress levels, decreased emotional wellbeing, reduced coping strategies and lower work performance.

We all experience stress at different times, to varying degrees. When we feel that work is leading to concrete, achievable and worthwhile goals, we almost always rise to the occasion, even with severe difficulties. Where there are urgent deadlines, work overload, poor relationships or other stressors, we mostly cope – if there is a return to 'normal' in a reasonable time. But, when a 'stressful' situation is ongoing or severe or has the potential to cause mental or physical illness, then it becomes a concern. In these cases the *HSE Act* requires the situation to be managed.

Work related stress is not an illness, but can lead to increased problems with ill health, if it is prolonged or particularly intense. Examples are heart disease, raised blood pressure, regular headaches, back pain, gastrointestinal disturbances and various minor illnesses. Psychological effects can be anxiety and depression.

You should take proactive steps to make work healthy, build morale, identify and deal with stressors, and talk with workers.

## 15.10 ULTRAVIOLET RADIATION

Short term exposure to the sun can result in sunburn and eye injuries. Prolonged exposure to sunlight is a well-established cause of skin cancer, including melanoma. It is the ultraviolet (UV) radiation component of sunlight which is harmful. Even on cloudy days, the UV level may be sufficient to be harmful. Long-term effects on the eye include damage to the cornea, and formation of cataracts.

The risk of skin cancer is higher for outdoor workers because of their prolonged sun exposure. Intense periods of exposure to the sun appear to be the most significant factor for melanoma. While people with certain skin types may be at greater risk, it is important that everyone protects their skin from prolonged exposure to solar UV radiation.

Workers may be exposed to non-ionising radiation from arc welding. People working near welding operations are at risk of "arc eye", a painful condition.

You must ensure the risk posed by exposure to UV radiation is reduced. In some instances, this may be achieved by simply changing the time of day when a task is carried out. Where this is not practicable, protection should be provided including working undercover and providing personal protective equipment.

## 15.11 CONTAMINATED LAND

Redevelopment of contaminated land, which may be associated with opencast mining or quarrying, can result in exposure to contaminants. The health effects, control measures and surveillance required will depend on the nature of the contaminants encountered. Specific advice from an occupational medical specialist should be sought before redevelopment commences.

## 15.12 HAZARDOUS SUBSTANCES

Hazards associated with hazardous substances depend on the type of substance and the environment in which it is being used. You should change processes to eliminate exposure to hazardous substances, or replace them with safer alternatives. Refer to the Safety Data Sheet (SDS) for the precautions required for each individual substance.

### 15.12.1 MERCURY

Mercury can be present in precious and base metal ore and is produced as a by-product of gold and silver processing. Mercury is a very toxic cumulative poison which can affect the brain, the central nervous system and the reproductive system. It can be absorbed by inhalation, ingestion and through the skin.

Mercury poisoning can result from both acute and chronic exposures. It is critical to recognise that exposure to mercury can be without warning and workers may not know the extent to which they have been contaminated. Personal, environmental and biological monitoring should be done to determine the exposure hazard and evaluate symptoms, as necessary.

Information, training, and supervision on the hazards associated with mercury should be given to workers on site.

For more detailed information see:

> Safety Data Sheets for precautions and other hazardous substance information.

> WorkSafe Workplace Exposure Standards (WES).

> Territorial authority plans (regional or district councils) for environmental standards.

> USA Department of Labor Mine Safety and Health Administration (MSHA) 'Best Practices' section of the Controlling Mercury Hazards in Gold Mining: A best practices toolbox for hazard controls.

## 15.13 DRUGS AND ALCOHOL

People may be under the influence of alcohol or drugs while at work. Workers have a duty to take all practicable steps to ensure their own safety, and alcohol and drugs may affect their ability to do this. This applies whether they are injected, inhaled or taken orally. The increased availability of stronger over the counter legal medication and other prescription medication means the risk of drug-impaired performance by workers may be increasing. The abuse of drugs or alcohol can be on-site or off-site, such as heavy drinking the night before a day shift.

All operations, large and small, can benefit from an agreed drug and alcohol policy, applying to all workers. Such a policy should form part of your organisation's overall health and safety policy. A written drug or alcohol policy has many advantages, including leaving less room for misunderstanding. Key elements of a drug or alcohol policy include:

> a statement on why the policy exists and who it applies to

- who is responsible for enforcing the policy
- a definition of drug or alcohol misuse
- how the operation expects workers to behave
- statements that make it clear how absence for treatment and rehabilitation will be recorded. Examples include sick leave, recognition that relapses may occur and how these will be dealt with, and how the policy will be reviewed and consulted on
- a statement on confidentiality so workers can be assured a drug or alcohol problem will be treated in strict confidence, subject to law
- a description of support available to workers who have a drug or alcohol problem
- a commitment to providing workers with general information about the effects of drugs or alcohol
- the circumstances in which disciplinary action will be taken.

The policy should also outline site rules for workplace events where alcohol is being served. This may include:

- approving any event where alcohol may be served
- carefully managing alcohol consumption
- designating drivers or providing transport if travel is needed after an event
- ensuring non-alcoholic refreshments and food are available
- keeping work vehicle keys safe
- making sure workers do not work after the event if they're still affected by alcohol (including the next day where relevant).

It is an offence to supply alcohol to anyone under 18 without parental consent.

## 15.14 PERSONAL PROTECTIVE EQUIPMENT (PPE)

PPE should only be considered as a hazard control where you have not been able to eliminate or isolate the hazard. PPE should always be used in conjunction with a documented safe system of work.

Employers must provide all appropriate PPE to employees and make sure it is used correctly, inspected, and maintained to fulfil its protective function and workers are trained in its correct use[86].

Where the following types of PPE are required the specifications and use of these are detailed below:

### 15.14.1 HIGH-VISIBILITY CLOTHING

High visibility clothing should comply with *AS/NZS 4602.1 High visibility safety garments – Part 1: Garments for high risk applications* or any other Standard embodying the same or more stringent criteria.

High visibility clothing should be worn on the outside of other clothing and not cause additional hazards (eg entanglement).

### 15.14.2 SAFETY FOOTWEAR

Workers engaged in extractive operations should wear protective footwear which provides foot and ankle support, traction and protection appropriate to the task they perform.

Where footwear requires protective toe caps they should comply with *AS/NZS 2210.1 Safety, protective and occupational footwear – Guide to selection, care and use* or any other Standard embodying the same or more stringent criteria.

When fitted, laces should be securely tied at all times.

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[86] *HSE Act*, sections 10 (2) (b) and 19 (a)

#### 15.14.3 SAFETY HELMETS

Safety helmets should comply with *AS/NZS 1801 Occupational protective helmets.*

Helmets should be inspected regularly for damage and deterioration.

Helmets should be replaced immediately if damaged, or three years after the issue date (if recorded), or in accordance with the manufacturer's specifications. Where the issue date is not recorded the helmet should be replaced three years after the manufacture date which is moulded into the peak of the helmet.

#### 15.14.4 HEARING PROTECTION

Hearing protectors should comply with *AS/NZS 1270 Acoustics – Hearing protectors,* or any other Standard embodying the same or more stringent criteria.

#### 15.14.5 EYE PROTECTION

Eye protection should comply with *AS/NZS 1337.1 Personal eye protection – Eye and face protectors for occupational applications,* or any other Standard embodying the same or more stringent criteria.

People who wear prescription glasses can have these made to comply with the above standard, or alternatively safety glasses or goggles that can be fitted over prescription glasses are available.

#### 15.14.6 GLOVES

Gloves should comply with *AS/NZS 2161.2 Occupational protective gloves, AS/NZS 2161.3 Occupational protective gloves – Protection against mechanical risks* or any other Standard embodying the same or more stringent criteria.

#### 15.14.7 FALL ARREST SYSTEMS AND DEVICES

Fall arrest systems and devices should comply with *AS/NZS 1891.1 Industrial fall-arrest systems and devices – Part 1: Harness and ancillary equipment* and *AS/NZS 1891.3 Industrial fall-arrest systems and devices – Part 3: Fall-arrest devices,* or any other Standard embodying the same or more stringent criteria.

Fall arrest systems should never be used as a primary hazard control.

Develop a rescue plane before using a harness system. It is critical that a suspended worker can be promptly rescued.

A worker suspended in a harness can develop suspension intolerance. This is a condition in which blood pooling in the legs can lead to loss of consciousness, renal failure and, in extreme cases, death.

For more information refer to section 6.5 of WorkSafe's *Best Practice Guidelines for Working at Height in New Zealand*.

#### 15.14.8 RESPIRATORY PROTECTIVE DEVICES

Respiratory protective devices used when there is potential for harm to persons exposed to dust, fumes, gases or chemicals should comply with *AS/NZS 1715 Selection, use and maintenance of respiratory protective equipment* and *AS/NZS 1716 Respiratory protective devices,* or any other Standard embodying the same or more stringent criteria.

#### 15.14.9 HAZARDOUS SUBSTANCE HANDLING

Personal protective clothing should be worn during the handling, mixing and application of chemicals or other hazardous substances.

The protective clothing to be worn should comply with the instructions detailed on the manufacturer's safety data sheet (SDS) for the specific substance being used.

PART D

# 16/

## PREVENTING FALLS FROM HEIGHT

### IN THIS SECTION:

16.1 Climbing on or off vehicles

16.2 Access and egress to heavy vehicle working areas

16.3 Covering loads

16.4 Access to fixed plant and machinery

16.5 Portable ladders

16.6 Working near highwalls or faces

## Many falls from height are caused by a failure to plan and organise work properly. Start by planning a safe approach.

This section describes how to prevent falls when:

> climbing on or off vehicles
> working around heavy vehicles
> covering loads
> accessing machinery
> using ladders
> working near highwalls or faces.

There is a reasonably good understanding in the extractives industry that if the distance of a possible fall is greater than 3 metres, all practicable steps must be taken to prevent any fall from occurring. The *HSE Act* requires steps to be taken to prevent the fall from occurring if there is any chance of harm resulting, even if a possible fall is less than 3 metres.

Regulation 21 of the *Health and Safety in Employment Regulations 1995* is the source of the often-quoted "3 metre rule". It is mistakenly believed that no further action is needed where a person could fall less than 3 metres. That belief is wrong and ignores the overall duties in the *HSE Act*.

Where the hazard of a fall exists you must consider, in this order:

(1) Whether the job can be done without exposing a person to the hazard (eliminate). In some cases elimination may be achieved at the design and purchasing stages. For example, maintenance activities able to be carried out at ground level.

(2) If elimination is not practicable, steps should be taken to isolate people from the hazard. This can be achieved using safe working platforms, guardrail systems, elevated work platforms, scaffolds or mobile scaffolds.

(3) If neither elimination nor isolation are practicable, steps should be taken to **minimise** the likelihood of any harm resulting. This may include use of safety harnesses or other types of fall restraint or fall arrest systems.

For more detailed information on preventing falls from height see the WorkSafe *Best Practice Guidelines for Working at Height.*

### 16.1 CLIMBING ON OR OFF VEHICLES

Access to heavy vehicles should be by a well-constructed ladder or steps. Ladders or steps should be well built, properly maintained and securely fixed. Where steps or ladders extend to the ground, the use of interlock systems is required to prevent the vehicle moving or starting until the ladder or step has been correctly stowed.

Avoid using suspended steps wherever practicable. If they cannot be avoided, use rubber or cable suspension ladders, not ladders made of chains. Ladders and steps should slope inward towards the top if this is reasonably practicable. They should not slope outwards towards the top.

Rungs or steps on vehicles should:

> be level and comfortable to use
> have a slip-resistant surface
> not allow, for example, mud, grease, or oil to build up dangerously (eg grating could be used to allow things to pass through a step).

The first rung or step should be close enough to the ground to be easily reached – ideally about 40 cm and never more than 70 cm. Place ladders or steps as close as possible to the part of the vehicle requiring access.

Opening (and holding open) a cab door on a vehicle should not force a driver to break the 'three point hold' rule or to move to an unsafe position.

Vehicle owners should consider retrofitting safer access ways to eliminate the risk of falling (refer Figure 92 and Figure 93).


**Figure 92:** A stairway and platform were retrofitted to this haul truck to increase driver access and egress safety (photo courtesy of Newmont Waihi and MacMahon)


**Figure 93:** This excavator has a good access system, with platforms, guardrails, kick plates and ladder. The ladder is interlocked so the vehicle cannot be started without the ladder being raised (photo courtesy of Newmont Waihi and MacMahon)

## 16.2 ACCESS AND EGRESS TO HEAVY VEHICLE WORKING AREAS

Wherever practicable, use walkways. Walkways should be made of slip-resistant grating (with enough space for mud or oil to pass through the grate and away from the walkway surface) or another slip-resistant material.

To prevent thrown mud from making them slippery, position walkways, steps, ladders, and handrails away from wheels if possible.

Top and middle guard rails may be needed to protect people when they are standing or crouching. Consider collapsible rails.

Vehicle owners should consider fitting guardrails if they are not already present (refer Figure 94). If features are retrofitted to existing vehicles, the alterations should not affect the structural integrity of the vehicle or the visibility of the operator.


**Figure 94:** Guardrails were retrofitted to this excavator to protect workers accessing the top of the machine for maintenance purposes (photo courtesy of NZ Steel, Taharoa)

## 16.3 COVERING LOADS

Loads must be covered whenever there is a risk of load shedding due to wind action or movement when travelling on a public road[87]. Covering loads or removing covers can be hazardous, especially when carried

[87] The Truck Loading Code – specialised requirements (Loose bulk loads)

out manually. You must consider the risks associated with load covering and take effective measures to make sure covering and uncovering loads is done as safely as possible. Consider the types of loads and vehicle, how often covering or uncovering happens and other specific characteristics of the workplace.

There are several but some options are better than others. A method of covering and uncovering that does not involve getting on to the vehicle or even touching the cover should be the first choice.

A hierarchy of solutions may look something like this:

> leaving the load uncovered if it is safe to do so
> using automated or mechanical covering systems which don't require people to go up on the vehicle (refer Figure 95)
> using manual covering systems which don't require people to go up on the vehicle (refer Figure 96)
> using work platforms to provide safe access to carry out covering from the platform without having to access the load (refer Figure 97)
> using gantry or harness systems to prevent or arrest a fall (refer Figure 98).

Consider the following points whatever method of covering is used:

> Do not overload the vehicle and try to load evenly to avoid the need for trimming. Load evenly along the length of the vehicle (not in peaks) or use a loader to pat down the load to flatten peaks.
> Train and instruct staff on safe systems of work (and provide refresher training where necessary). Supervise and monitor covering and uncovering activities.
> Regularly check covers are in good condition, and replace when necessary. Visually check straps and ropes used for pulling and securing the cover.
> Regularly inspect, repair and maintain covering mechanisms, platforms, gantries and fall-arrest equipment (like harnesses and lanyards).
> During loading, unloading and covering, consider vehicles used by workers of more than one company 'shared workplaces' and arrange for suitable controls to be followed by everyone concerned.
> Ropes, straps and covers can snap or rip. The driver should avoid leaning backwards when pulling the cover tight.
> Park vehicles on level ground, with their parking brakes on and the ignition key removed.
> Cover vehicles before leaving the site.

However it is done, carry out covering and uncovering in designated places, away from passing vehicles and pedestrians and, where possible, sheltered from strong winds and bad weather.

**Figure 95:** Automated covering system

**Figure 96:** Manual covering system

**Figure 97:** Platform covering system

**Figure 98:** Overhead gantry harness system

## 16.4 ACCESS TO FIXED PLANT AND MACHINERY

For information on access to fixed plant and machinery see section 12.7.

For information on preventing falls while undertaking maintenance on fixed plant and machinery see section 17.1.1.

## 16.5 PORTABLE LADDERS

Portable ladders should comply with *AS/NZS 1892.1 Portable ladders* metal or any other Standard embodying the same or more stringent criteria.

All portable ladders should have their safe working load certified by the manufacturer and be inspected prior to every use for any damage.

Portable ladders should be used for low-risk and short-duration tasks. The user should maintain three points of contact with a ladder or stepladder to reduce the likelihood of slipping and falling. Ladders and stepladders do not offer fall protection and therefore should be the last form of work access equipment to be considered.

For more information on ladders and stepladders see WorkSafe *Best Practice Guidelines for Working at Height in New Zealand.*

## 16.6 WORKING NEAR HIGHWALLS OR FACES

Any person who works on or near the edges of faces or highwalls has the potential to fall. Typically these are the driller, shot-firer and person carrying out the daily inspection. Other people potentially working on or near edges are surveyors, engineers, explosives truck workers, planners, geologists, geotechnical engineers and fencers.

A hierarchy of control is:

> A windrow, a fence or other physical barrier capable of supporting a person's weight if they fall against it should be in place along the edge (refer Figure 99).

> If a barrier is not practicable, you should determine a distance from the edge that is safe to work and demarcate this area with a fence (ie para-webbing fence or warratah wire type fencing). The safe distance should be a minimum of two metres (refer Figure 100).

When installing or removing any barrier other than a windrow, provide a travel restraint system such as a harness. Connect this harness to a fixed position that restricts workers' ability to work outside the safe area (refer Figure 101).

A risk assessment should be carried out to establish a safe system of work for any person likely to be in a position where they may fall from a face. Consider the geology and stability of the face, the ground conditions, weather, lighting equipment being used, the need to adjust burdens, marking hold positions and profiling.

Windrows are preferable to other less substantial barriers but may hide cracks or signs of instability along the edge (refer figure 99). Windrows should be:

> constructed only after inspection of the area below. Faces need to be inspected for faults, change in appearance, loose surface, evidence of falling rocks, water seepage, joints and cracks

> constructed a metre or two from the edge where possible so any cracks or deterioration of the edge can be seen

> constructed from suitable material to avoid trip hazards

> a minimum height of one metre (for pedestrian protection only)

> regularly inspected and maintained.

Workers should be trained in the appropriate selection and use of harnesses before starting work. Make sure workers are closely supervised until assessed as competent.

Vehicles should not be parked under high walls, due to the hazard of rock falls.

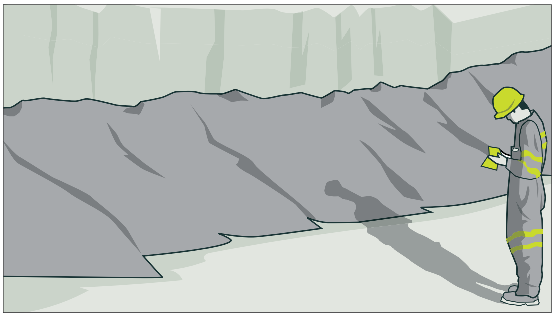

**Figure 99:** Example of a pedestrian windrow


**Figure 100:** Example of non-weight supportive barriers

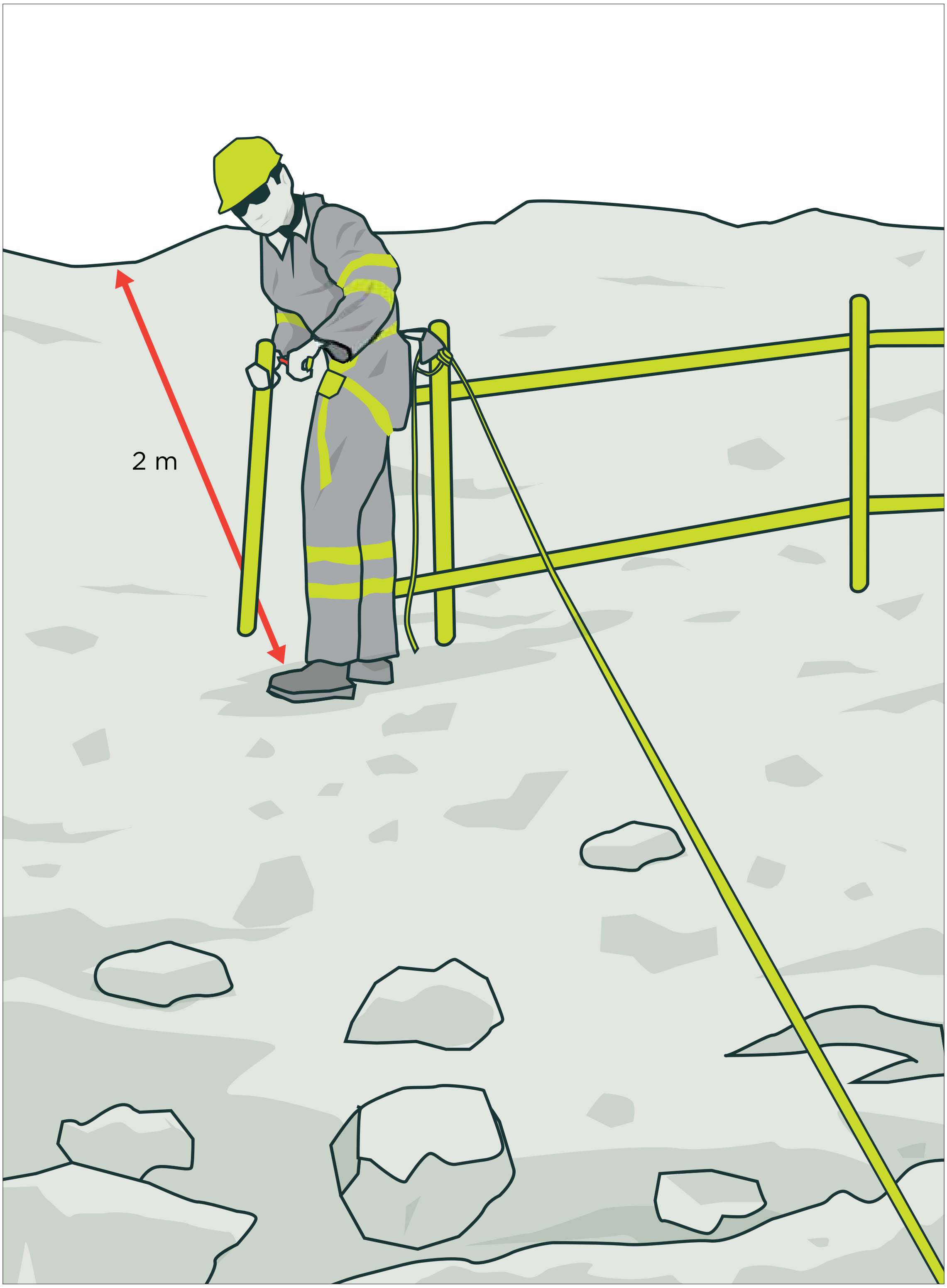


**Figure 101:** Example of fall restraint system

PART D

# 17/

# MAINTENANCE AND REPAIRS

## IN THIS SECTION:

17.1 Common hazards when undertaking maintenance

17.2 Isolation and lockout of energy

17.3 Permit to work systems

17.4 Inspecting and servicing vehicles

17.5 Hazardous substance storage

17.6 Blocked crushers or hoppers

## Tasks such as maintenance, repairs, servicing, clearing blockages and cleaning can be dangerous. Workers can be fatally or seriously injured if they don't manage the risks carefully.

This section describes how to:

> identify and manage common hazards including falls, energy sources, confined spaces and equipment for welding or cutting

> isolate equipment and use safe lockout and permit procedures to keep workers safe

> inspect and service vehicles safely

> prevent and clear blockages in crushers or hoppers.

You must establish a maintenance and inspection programme to ensure equipment and machinery is safe to use. Maintenance and inspection programmes should take into account:

(a) the operational environment the machinery or vehicles are being used in, particularly where subject to corrosion or rot

(b) the original equipment manufacturer's recommendations.

Maintenance and inspection programmes should take into account the whole of the machinery or vehicles including, as appropriate:

> the structure of the machinery (bracing, supports)

> safety features (ie emergency stops, guarding, emergency equipment, props)

> integrity of walkways, stairs, ladders, railings or guardrails

> integrity of holding vessels (ie tanks, hoppers)

> integrity of lifting equipment (ie chains, strops, hooks, gantry cranes, lifting eyes, quick hitches)

> signage and other warning devices (ie lights, alarms).

Mine operators must ensure a competent person examines any machinery that has been stopped for the preceding 24 hours or longer before it is started. In addition the mine operator must ensure a competent person examines every accessible area of the site. Include every area containing barriers, machinery and surface infrastructure at least weekly and every area where a worker, is or will be, before every shift and during shifts as required[88]. A written procedure must be included in the health and safety management system setting out:

> what will be examined

> when it will be examined

> how findings will be recorded

> how findings will be actioned[89].

For more detailed information on inspection and maintenance of machinery, including safe systems of work, see the WorkSafe *Best Practice Guidelines for the Safe Use of Machinery.*

[88] The Regulations, regulation 222(1)
[89] The Regulations, regulation 222(2)

## 17.1 COMMON HAZARDS WHEN UNDERTAKING MAINTENANCE

Undertaking maintenance activities (including cleaning) can potentially expose workers (and others) to significant hazards. The following five hazards merit particular attention.

### 17.1.1 FALLS FROM HEIGHT

Maintenance work often involves using access equipment to reach raised sections of machinery or vehicles. Eliminating the need to access machinery or vehicles at height by careful design is the most effective control.

Where elimination is not practicable, and frequent access is required, platforms, walkways, stairways and ladders that comply with the *Building Code* should be provided. Where infrequent access is required suitable temporary access equipment with adequate barriers or fall restraint systems should be used.

For more detailed information on platforms, walkways, stairways and ladders see the Department of Building and Housing *Compliance Document for New Zealand Building Code Clause D1 Access Routes and Compliance Document for New Zealand Building Code Clause F4 Safety from Falling.*

**Note:** *The Compliance Document for New Zealand Building Code Clause D1 Access Routes (NZBC D1) specifies AS/NZS 1657* as an acceptable solution for fixed platforms, walkways, stairways and ladders for access routes for service and maintenance personnel. Provision in *AS/NZS 1657* may exceed the requirements of *NZBC D1*.

For more information on preventing falls from height see section 16.

### 17.1.2 FALLS OF HEAVY ITEMS

Heavy items sometimes have to be moved, or get disturbed, during maintenance work. If one of these falls, the results can be fatal.

Incidents can include:

> the failure of lifting equipment
> inappropriate lifting and slinging practices
> inadequate supports or supports not resting on level or firm ground
> incorrectly estimating the weight or centre of gravity of the load
> rocks falling from trap points on mobile plant or the headboards of haul trucks.

If a heavy item has to be moved or temporarily supported during maintenance work, it is crucial the risks are assessed and a plan of action is properly thought through. The people responsible for the maintenance work shouldn't presume that things will be okay, that others will know what to do, or the right equipment will necessarily be available. These lifts, or the use of temporary supports may be 'one offs' and will inevitably require more knowledge and skill than routine production tasks.

Make sure:

> everyone involved in maintenance understands the risks
> an assessment of the risks (including the risk of disturbing something inadvertently) is completed and a plan of action decided on, before a heavy item is moved or temporarily supported
> there is someone competent to provide advice on safe slinging and on safe working practices for work involving heavy loads
> any equipment used to lift or support a heavy load is suitable and (where necessary) has been inspected and tested by a competent person

> heavy items are not left unsecured where they may tip over, fall or slip, and no-one works under suspended loads
> equipment is thoroughly cleaned with any loose material removed before maintenance activities commence.

### 17.1.3 ENERGY SOURCES OR STORED ENERGY

Isolation and lock out arrangements, and in some cases permits to work, are essential to enable maintenance work to be conducted safely.

Before any maintenance work is undertaken you should:

> isolate the power or energy source (usually, but not exclusively, electrical energy)
> apply an isolation device and a sign to indicate that maintenance work is in progress
> dissipate any stored energy (eg hydraulic or pneumatic power
> test and verify isolation is correctly applied.

For more detailed information on isolation systems, see section 17.2.

### 17.1.4 CONFINED SPACE ENTRY

A ‘confined space’ is a place which is substantially (though not always entirely) enclosed, and where there is a risk of death or serious injury from hazardous substances or dangerous conditions (eg lack of oxygen). These can include tanks, load out bins, reclaim tunnels, crushers, and poorly ventilated rooms.

You should minimise the time that tasks are undertaken in the confined space. This may be achieved by partially dismantling machinery or undertaking work outside the confined space before entry.

Where confined space entry is required, WorkSafe accepts A*S 2865 Confined Spaces* as the current state of knowledge on confined space entry work.

For more detailed information see, *AS 2865 Confined Spaces* and *WorkSafe Safe Working in a Confined Space.*

### 17.1.5 WELDING AND GAS CUTTING

Welding can have acute, chronic and long-term hazards to health and safety. These can act quickly or may show up only in the long term.

WorkSafe has adopted the following documents, published by the Welding Technical Institute of Australia (WTIA), as its main sources of advice about health and safety in welding:

> Health and Safety in Welding 2004 – Technical Note 7 (TN7).
> Fume Minimisation Guidelines (FMG).

WorkSafe’s *Health and Safety in Welding* publication summarises some of the main points in the relevant sections of both the above publications.

In addition, the *Welding Health and Safety Assessment Tool* is available on the WorkSafe website (www.business.govt.nz/worksafe/). The tool is a detailed assessment to assist in auditing workplaces where electric or gas welding or cutting is carried out. The aim of the audit is to lead a discussion through the essential elements of welding or cutting safe practice so that workplace participants may decide where improvements are required.

Oxygen under pressure and oil or grease can react violently, causing fire and explosions. Do not allow oxygen under pressure and oil or grease to come into contact.

Welding hazards include:

**Fires and explosions:** These are an ever-present hazard with many welding processes.

**Burns:** Welding causes items to become hot, creating a risk of burns and fires from hot metal and welding spatter.

**Fumes:** Fumes generated by different welding processes may range from being of nuisance value to highly toxic. Health effects can occur very soon after exposure (eg exposure to cadmium fumes can be fatal within hours) or may not result until after many years. Fume control requires appropriate ventilation equipment and may require advice from a specialist.

**Electric shock:** Welding processes that use electricity pose both obvious and subtle hazards of electric shock – which can be fatal. Take standard precautions, as explained in the WorkSafe *Health and Safety in Welding* publication, when using welding equipment. Expert assistance can be needed in some circumstances to identify subtle hazards. Appropriate equipment selection, set-up and maintenance is important and may require specialist advice to ensure safety.

**Compressed gases:** Compressed gases in cylinders pose a number of hazards. Safe use methods are outlined in *TN7* section 5.

**Hazardous substances:** Hazardous substances used during some welding processes can require highly specialised methods of control (eg extremely toxic hydrofluoric acid). Use a specialist in these situations.

**Toxic gases:** Precautions for preventing toxic gases from causing harm are outlined in *TN7* sections 5 and 10. Toxic gases may be:

> used in or generated by the process (eg acetylene, ozone, nitrogen oxides, carbon monoxide)

> generated when coatings on metal surfaces are heated (eg galvanised steel, epoxy resins, degreasing agents, paint)

> generated when the arc flash and some degreasing chemicals or paints react (eg phosgene or phosphine).

**Suffocation**: Inert gases used during welding can flood an area and lower its oxygen content, especially in confined spaces. Suffocation can result. For more detailed information on confined space entry see section 17.1.4.

**Radiation:** Arc flash is a well-known hazard of welding. Standard precautions (PPE) should be used to prevent eye and skin exposure – for the worker and others in the vicinity. Reflecting surfaces make exposure to radiation more likely. For more information on PPE requirements see *Health and Safety in Welding.*

**Heat stress:** Working for long periods in hot environments can lead to distress and in an extreme, fatal heat stroke. Specialist advice must be sought if welders work in hot environments (see *TN7* section 23). For more information on heat stress see section 15.6.

**Dust:** Associated processes (grinding) may generate hazardous levels of dust. For more information on dust see section 15.5.

**Noise and vibration:** Noise and vibration levels during some welding processes can be high and should be controlled or appropriate hearing protection should be worn. For more information on noise and vibration see sections 15.3 and 15.4.

**Manual handling:** Some welding processes may involve heavy or repetitive handling. For more detailed information on manual handling see section 15.7.

**Specific processes:** Several processes are discussed in *TN7*:

> plasma cutting

> brazing and soldering

> thermal lancing.

Providing health and safety information and advice on welding and cutting processes can be complex. There are many subtleties and traps for the unwary or inexperienced. Specialist advice may be required.

## 17.2 ISOLATION AND LOCKOUT OF ENERGY

Energy isolation is much more than putting a lock and tag on a switch. To effectively isolate workers from energy you need to know what energy is, and how it can be safely isolated on specific machinery and vehicles.

More information on isolation and lockout of energy can be found in Appendix N: Isolation and lockout of energy. This includes information on the following:

> What are types of energy?
> Energy isolation procedures.
> Is lockout and energy control the same thing?

### 17.2.1 LOCKOUT AND TAG OUT SYSTEMS

Lockout and tag out systems are the placement of a lock and tag on an energy-isolating device. They indicate that the energy-isolated device is not to be operated until removal of the lock and tag in accordance with an established procedure.

Lockout is the isolation of energy from the system (a machine, equipment or process) which physically locks the system in a safe mode. The locking device (or lockout device) can be any device that has the ability to secure the energy-isolating device in a safe position (ie lock and hasp).

Tag out is the labelling process that is used when lockout is required. The process of tagging out a system involves attaching or using an indicator (usually a standardised label) that includes the following information:

> Why the lockout and tag out is required (eg repair or maintenance).
> The date and time the lock and tag was attached.
> The name of the authorised person who attached the lock and tag to the system.

**Only** the authorised person who put the lock and tag onto the system is allowed to remove them. This procedure helps to ensure the system cannot be started up without the authorised person's knowledge.

WHY LOCKOUT AND TAG OUT ARE IMPORTANT

Safety devices such as guards or guarding devices are installed on systems to maintain worker safety while these systems are being operated. When performing non-routine activities these safety devices may be removed but there must be alternative methods in place to protect workers from the increased risk of injury of exposure to the accidental release of energy. Non-routine activities include maintenance, repair, set-up, or the removal of jams or misaligned feeds.

The main method used and recommended to protect workers from risk of harm in these cases is the use of a lockout and tag out procedure (LOTO).

A LOTO procedure will prevent:

> contact with a hazard while performing tasks that require removal, by-pass, or deactivation of safe guarding devices
> unintended release of hazardous energy (stored energy)
> unintended start-up or motion of machinery, equipment or processes.

LOCKOUT PROCEDURES AND WORK INSTRUCTIONS

The written lockout procedure should identify:

> what needs to be done
> when it needs to be done
> the tools available to do it
> who is supposed to do it
> who needs to be notified.

Work instructions should identify how the lockout process is to be carried out in a step-by-step process including how stored energy is controlled and de-energised, how isolation can be verified, and how and where lockout devices are installed. Work instructions should be machine, equipment or process specific and include pictures or images of what is being described.

There should be one lockout procedure, and as many sets of work instructions as required, depending on the number of systems that require lockout.

For more information on lockout systems and isolation procedures, including responsibilities, see the WorkSafe *Best Practice Guidelines for Safe Use of Machinery.*

For more detailed information on writing health and safety documents, see WorkSafe's *Writing Health and Safety Documents for your Workplace.*

## 17.3 PERMIT TO WORK SYSTEMS

A Permit to Work (PTW) system is a formal documented process used to manage work identified as significantly hazardous by making sure all safety measures are in place before work starts.

A PTW system is also a way to communicate between site management, plant supervisors, operators and those who carry out the hazardous work. Essential features of a PTW system are:

- clear identification of who may authorise particular jobs (and any limits to their authority) and who is responsible for specifying the necessary precautions
- training and instruction in the issue, use and closure of permits
- monitoring and auditing to make sure the system works as intended
- clear identification of the types of work considered hazardous
- clear and standardised identification of tasks, risk assessments, permitted task duration and supplemental or simultaneous activity and control measures.

The terms 'permit to work', 'permit' or 'work permit' refer to the paper or electronic certificate or form used to authorise certain people to carry out specific work at a specific site at a certain time. It also sets out the main precautions needed to complete the job safely.

### 17.3.1 WHEN ARE PERMIT-TO-WORK SYSTEMS REQUIRED?

Consider permit-to-work systems whenever the intention is to carry out particularly hazardous work. PTW systems should not be applied to all activities, experience has shown their overall effectiveness may be weakened. Permits-to-work are not normally required for controlling general visitors to site or routine maintenance tasks in non-hazardous areas.

Permit-to-work systems are normally considered most appropriate to:

- non-production work (ie intrusive maintenance, repair, inspection, testing, alteration, construction, dismantling, adaption, modification or cleaning)
- non-routine operations
- jobs where two or more individuals or groups need to co-ordinate activities to complete the job safely
- jobs where there is a transfer or work and responsibilities from one group to another (ie shift changeovers).

More specially, the following are examples of types of jobs where permits could be considered:

- work of any type where heat is used or generated (eg by welding, flame cutting, grinding) and work which may generate sparks or other sources of ignition
- work which may involve breaking containment of a flammable, toxic or other dangerous substance or pressure system, and work involving the use of hazardous or dangerous substances, including explosives
- work on high voltage electrical equipment or other electrical equipment which may give rise to danger

> entry and work within confined spaces
> pressure testing
> work affecting evacuation, escape or rescue systems
> work at height
> any other potentially high-risk operation.

### 17.3.2 PERMIT TO WORK SYSTEM PROCESS

For more information on the permit to work system process, please see Appendix O: Permit to work system process.

## 17.4 INSPECTING AND SERVICING VEHICLES

Vehicles at extractive sites work in harsh environments and require effective maintenance to avoid developing defects. Establish a programme of daily visual checks (or pre-start checks), regular inspections and servicing schedules according to the original vehicle manufacturer's instructions, and the risks associated with the use of each vehicle.

Inspections and maintenance should include, where appropriate:

Vehicle Control

> braking systems
> steering
> tyres, including condition and pressures
> safety devices such as interlocks.

Driver Safety

> seats and seat belts
> mirrors, cameras and other visibility aids
> lights and indicators
> warning signals
> windscreen washers and wipers
> firefighting equipment.

Vehicle Maintenance

> condition of cab protection devices (such as ROPS and FOPS)
> condition of tailgates
> condition of hydraulic pipes and hoses
> fluid levels
> functional checks on the vehicle
> other accessories such as quick hitches.

Where vehicles are hired, determine who is responsible for maintenance and inspection during the hire period and make this clear to all parties.

Put in place a safe system of work that addresses issues such as safely blocking the vehicle and its attachments, isolating stored energy (ie gravity) and preventing the vehicle from inadvertently being started. When using jacks they should be rested upon suitable load bearing substrata. Raised objects should be lowered wherever practicable (eg excavator or loader buckets).

Determine a procedure to address defects where they are found in vehicles or attachments.

Such procedures could include:

> recording defects when completing daily visual checklists (pre-start inspections) scheduled inspections, daily visual checklists and maintenance logs
> establishing protocols for safety critical defects (when a vehicle should be removed from operation, time frames to fix specific defects and so on). For example, how deep does a cut in the tyre need to be before they should be replaced?
> a system to isolate vehicles when safety critical defects are found. For example keys or other starting devices removed and secured until repairs are started.

### MAINTENANCE UNDER HYDRAULICALLY RAISED PARTS OF VEHICLES

Many vehicles use hydraulics to raise, lift or move material or parts of the vehicle (eg truck trays, front end loader buckets, excavator booms and drilling rigs). These raised parts have stored energy and you must provide supports or other devices to prevent raised parts dropping or being lowered while workers are under them[90].

Consider:

> removing the elevated part before other maintenance work takes place (eliminate the hazard)

> fitting a restraining system to the elevated part

> fitting the tray or bucket with a built-in prop

> ensuring restraining system controls are clearly marked and shrouded or protected from accidental operation

> fitting hydraulic cylinders with over centre valves.

### BRAKE TESTING

A suitable inspection scheme should be in place to ensure brakes are in good condition at all times. This is often combined with other maintenance work.

Electronic brake testing equipment is available to regularly and accurately measure brake performance (eg an electronic system may be permanently fitted in a haul truck). This will show deficiencies in the brake system before they become a problem. The site Health and Safety Management System should require operation, monitoring and maintainance of brake systems according to original vehicle manufacturer (OVM) recommendations, as a minimum.

It should be ensured that:

> the driver tests the brakes at the start of every shift (pre-start inspection), including the park brake and foot brake

> the condition of brake system components is monitored according to OVM's recommendations, reducing the likelihood of catastrophic failure and ensuring they continue to function as intended

> brake system performance is tested according to OVM's recommendations in both static and dynamic situations

> drivers and maintenance workers can access OVM operating and maintenance manuals at site as appropriate

> braking system repair, monitoring, inspection and testing records are readily available at site

> drivers and maintenance workers are trained in the relevant aspects of braking systems

> safety critical aspects of vehicle operation, including emergency braking systems, retarders and other controls available in the event of engine failure (eg accumulators), are incorporated into driver training and assessment processes, with appropriate input from competent maintenance workers

> operating and brake maintenance practices for contractors' vehicles are not inferior to the vehicle maintenance practices adopted by site*

> contractors' vehicles are not allowed to operate on site unless maintenance and testing records are checked to verify the integrity of brake systems*

> brake maintenance, including processes used for contractors' vehicles, is regularly audited for effectiveness*

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[90] Regulation 15 of the *Health and Safety in Employment Regulations 1995*

* **Note:** A "contractor" is a person engaged (other than as an employee) to undertake work at the site, not a customer

> if OVM manuals are unobtainable (eg due to the age of vehicle), prepare manuals so effective brake system operation and maintenance strategies can be established. Use people with appropriate skills and technical expertise to facilitate the process.

**Brake system maintenance strategies**

Correct brake system functioning depends on the condition of system components, which in turn depends on the quality of the maintenance. Any brake system maintenance strategy should focus on detecting and rectifying a defect before it results in a loss of brake function.

Brake system maintenance strategies should initially be based on the original vehicle manufacturer (OVM) recommended maintenance programs, and on condition monitoring, inspection and testing schedules. OVM stipulated operating procedures and repair techniques help make sure brake system integrity is not compromised.

The OVM information should be stored, maintained, updated and be readily accessible by relevant workers, whether it is in hard copy, electronic copy, or on-line based systems.

Hazard identification and risk assessment aimed at improving brake system reliability should consider anything that could affect the safe operation of vehicles. This could include site conditions, maximum loads, operating speeds, operating grades, effects of heat fade, component failure, and loss of pressure.

Controls needed may include more frequent component inspections for wear or damage, and regular brake performance verification techniques. These could include Dynamic Brake Testing (DBT), electronic brake test equipment and thermographic temperature profiling, to detect poor performance.

Note that a positive DBT result doesn’t necessarily verify brake system integrity or confirm the system has been maintained to OVM recommendations. It only indicates the brakes were effective at the time of testing.

In introducing a DBT program, the risk assessment to determine appropriate controls should consider, but not be limited to:

> OVM consultation on any deviations from the stated recommendations

> applying relevant brake performance testing standards or appropriate industry practice

> site facilities and limitations relating to surface, space, and controlling vehicles in case of brake failure during testing

> variations in test methodology and acceptance criteria for different vehicle types and categories (for more detailed information see *AS 2958.1-1995 Earth-moving machinery – Safety – Wheeled machines – Brakes*)

> reliability of the DBT test instruments

> applicability and integrity of the standards, procedures and methods used to interpret the results

> training and competency of workers conducting the tests.

**Industrial trucks and load shifting equipment (forklifts, mobile cranes)**

Inherent instability and lack of traction of forklifts and cranes, particularly on ramps and slopes, present a challenging risk management task. Operators should understand the brake system design limitations and that brake system monitoring, inspection, testing and maintenance are appropriate for the risks in particular applications.

The Australian Standard *AS 2359.13-2005 Powered industrial trucks – Brake performance and component strength* provides guidance on methods for assessing and testing the performance and components of brakes fitted to industrial trucks with rated capacities up to, and including, 50 tonnes.

Safe forklift operation on gradients largely depends on the type, size and design of the forklift. Ask the OVM if you're unsure of the braking system's performance capabilities.

For more detailed guidance on requirements for the operation, maintenance, repair and modification of industrial trucks see WorkSafe *Approved Code of Practice for Training Operators and Instructors of Powered Industrial Lift Trucks (Forklifts)*. Also see the supporting document *Safety Code for Forklift Truck Operators: Front Loading Forklift Trucks.*

### 17.4.2 TYRE SAFETY

The purpose of this section is to describe some of the hazards associated with tyres in service. There is also guidance and preventative measures to avoid or minimise those hazards when working with tyres or combating tyre fires, explosions and potential explosions.

This section deals with these hazards separately, but care should be taken to ensure overlapping areas are adequately dealt with in operating procedures.

WORKING WITH TYRES

Four major hazards when working with tyres:

- compressed air
- manual handling
- exploding or disintegration of wheels and tyres
- noise.

Lack of training or experience in the handling and maintenance of wheel and tyre assemblies (especially with bead lock systems) can increase risks.

**Compressed air**

The eyes are particularly at risk when compressed air is in use, both from high-velocity air and from particles of dust, metal, oil and other debris, which can be propelled by the air. Suitable eye protection should always be worn.

Suitable overalls or other substantial clothing will protect the skin from light particles and debris, provided they are not blown at a high velocity. However, overalls cannot offer protection against high-velocity air at close range. Particles can be blown through overalls and skin and into the body. Air can be blown into the bloodstream, causing swelling and intense pain, particularly if any cuts, punctures or sores are present, making entry easier. The air can be carried to the small blood vessels of the brain, lungs or heart, resulting in death. Workers should not use compressed air to dust themselves down.

All pressure gauges and control devices should be checked against a master pressure gauge at regular intervals or immediately after any heavy impact or other damage. Compressed air hand tools should be maintained and checked regularly.

Compressors and associated equipment such as air-receivers should be regularly inspected in accordance with a schedule of planned maintenance to make sure they meet legal requirements[91] and are safe to use.

**Manual handling of heavy objects**

The tyre and wheel assemblies of large vehicles are usually too heavy to be manually handled safely.

The safe handling of many loads encountered in the fitting and maintenance of large earthmoving tyres and wheel assemblies can only be undertaken using specialist tyre-handling equipment. Special attachments may be required on standard handling equipment (eg fork lifts) to deal appropriately with large tyres and wheels.

[91] *Health and Safety in Employment (Pressure Equipment, Cranes, and Passenger Ropeways) Regulations 1999*

**Exploding wheels and tyres**

Large tyres and wheel assemblies are heavy objects, but when they explode they are thrown violently by the force of the escaping compressed air. An exploding wheel is a high-speed projectile that can kill or seriously injure anyone in its path.

Divided wheel, split-rim and locking-rim wheel and tyre assemblies are especially likely to explode if poorly maintained, incorrectly fitted, or if assembled or disassembled while inflated.

The most common faults are:

> over-inflation
> removal of split-rim fastening nuts instead of wheel fastening nuts
> failure to ensure correct seating of split rims or tyre beads
> the use of damaged parts, or replacement parts with lower strength than the original equipment.

Non-original after-market nuts and bolts and other fixings could be inadequate.

It is essential to deflate tyres before wheel removal to ensure removing the wrong nuts does not result in a serious or fatal accident.

All off-road vehicles should have a maintenance system in place for rims and wheels in accordance with *AS 4457.1 Earth Moving Machinery – Off-the-road wheels, rims and tyres – Maintenance and repair – Wheel assemblies and rim assemblies.*

**Noise**

Hearing damage can affect tyre fitters just as easily as other at-risk occupations. Causes of noise-induced hearing loss are compressed air blowing freely, noise from impact wrenches and wheel parts and tools dropping on concrete workshop floors. Engineering solutions to manage excessive noise are preferred. The selection of air-tools for their noise-level characteristics should form part of the purchasing system.

Noise from steel impacting on concrete floors can be reduced with special floor surfaces or mats. Any residual noise must be dealt with by restricting the operators exposure. Where noise exposure cannot practicably be further reduced, hearing protection must be provided and its use must be enforced.

For more detailed information on noise management see the WorkSafe *Approved Code of Practice for Worker Health in the Extractives Industry.*

TYRE SAFETY CAGES AND EXCLUSION ZONES

It is strongly recommended all tyres, including small units, be inflated within a suitable restraint.

Tyres on split-rim and detachable-flange wheels should be contained by a cage guard, or other suitable restraining device, when being inflated after being dismantled or repaired.

Tyres that have a large volume, or are inflated to high pressures, should be contained by a cage guard or other restraining device when being inflated, after being repaired or otherwise removed from the wheel. This includes truck, forklift or earthmoving plant tyres.

If restraints are not available, a suitable system of work is to be used (eg inflating from behind a barrier).

Most car or light vehicle wheels and tyres are strongly constructed and have small internal air volume. They therefore do not require high pressures. Such tyres pose minimal risk to the service person and, if correct fitting procedures are adhered to, problems would not normally be expected. However, some light vehicles have divided wheels that require cage inflation. In general, inflate light vehicle tyres with the jaws of the tyre-fitting machine restraining the wheel.

## FIRES AND EXPLOSIONS OF TYRES IN SERVICE

### Mechanisms of tyre fires and explosions

The primary cause of tyre fires is the application of heat to the tyre, or development of heat within the tyre structure by one or more mechanisms. The same primary causes can result in a violent explosion of the tyre under some circumstances.

Heat can be conducted through the rim base to the bead area of the tyre where a small quantity of rubber can be pyrolysed. The gases given off in the process can be ignited by the continued application of heat. An explosion could originate from the point of heating, with the flame fronts travelling around the tyre in opposite directions and causing a rupture where they meet.

A temperature rise sufficient to cause problems can be generated by other sources of heat, such as:

> electrical earthing through the tyre as a result of lightning strike or power-line contact
> wheel component heating through misuse of brakes or electric-wheel motor problems
> internal tyre damage as a result of excessive speed, road camber deficiencies and ply separation.

A uninflated tyre may explode in the same manner as an inflated tyre if sufficient heat is applied to it.

Other factors that can increase the likelihood of a fire or explosion are:

> The auto-ignition temperatures of different types of bead lubricants and other introduced materials vary widely. Before any material is introduced into the tyre air chamber, its auto-ignition temperature should be checked, and if the figure is lower than that for the tyre liner or bead, it should not be used. Auto-ignition information can be found on a product's safety data sheet (SDS).
> The accidental use of an incorrect inflation medium (eg LPG or other explosive gases) through contaminated air supply or other means.
> Carbon dust given off from pyrolysis of the tyre liner. This dust can auto-ignite at temperatures as low as 200°C, the lowest auto-ignition temperature of any material likely to be encountered in a tyre.
> Low flash point fuels and solvents can be absorbed by tyre rubber. This can increase the likelihood of a tyre catching fire where a heat source is introduced, increase the seriousness of any fire that does eventuate, or both.

A tyre explosion can occur even where no fire is visible. Smoking tyres or brakes should be treated as a potential tyre explosion and the vehicle isolated accordingly.

### Prevention of tyre fires

To prevent tyre fires you should:

> ensure correct inflation of all tyres and check on a daily basis
> ensure no hot work is undertaken around the wheels and rims
> make sure trucks are not overloaded
> consider installing on-board tyre pressure and temperature sensors.

### Prevention of tyre explosions

To prevent tyre explosions consider implementing the options listed below:

> **Nitrogen inflation:** nitrogen inflation will significantly reduce tyre explosions.
> **Inhibiting agents:** Consider the use of fire inhibiting agents and fireproof coatings on the inner surface of the tyre.
> **Earthing vehicles:** Consider earthing vehicles against lighting strikes so the tyres do not provide the earthing path.

COMBATING TYRE FIRES AND POTENTIAL EXPLOSIONS

If a vehicle catches fire or a heat source is recognised and there is a potential for a tyre explosion, you should immediately establish a prohibited zone of at least 300 metres around the radius of the vehicle. The prohibited zone should remain in place for at least 24 hours following the removal of the heat source. An emergency crew should remain in attendance during this period.

For more detailed information on vehicle fires see section 11.9.7.

## 17.5 BLOCKED CRUSHERS OR HOPPERS

Clearing blocked crushers or hoppers can be very hazardous and many plant operators have been killed carrying out this task. Blockage incidents can be greatly reduced by supplying material that is sized to match the primary opening.

Preventing of oversize feed material starts at the face, with good fragmentation. Removing oversize material before delivery to the plant and vigilant control of the crusher feeder, will make blockages less likely.

Causes of crusher blockages can be grouped under two main headings:

**Stalling,** due to:

> electrical or mechanical failure
> material jammed in the chamber causing an overload
> overfeeding material
> entry of tramp metal or wood
> accumulation of material in the crash box
> accumulation of fine material in the crusher discharge chute.

**Bridging,** due to:

> oversize feed material
> excessive clay or other fines in the crushing cavity, preventing small material passing through the crusher
> a foreign body in the crusher feed or discharge chamber, obstructing the feed material.

### 17.5.1 PREVENTION

Every effort should be made to prevent oversize material or tramp metal entering the crusher feed hopper, by:

> designing any site blast to achieve optimum rock fragmentation
> training and instructing the loader driver not to load oversize material
> using sizing bars or grids on crusher feeds
> following the manufacturer's recommendations on the rate, presentation of feed and crusher settings
> instituting a programme of good housekeeping to prevent scrap steel entering into shovel buckets
> ensuring the bucket size is appropriate to the capacity of the crusher
> regular inspection of metal parts (eg bucket teeth, dumper wear plates and drilling components) to make sure they are unlikely to break off and enter the crusher feed
> the strategic placing of electrical magnets or the installation of metal detectors to prevent tramp metal from entering the crusher
> the use of level indicators for feed control
> maintenance of drive systems
> removal and adequate cleaning of the discharge chute.

A properly designed crushing operation should not need any person to be present on the crusher access platform during normal crushing operations.

### 17.5.2 CLEARING BLOCKAGES

BRIDGED CRUSHERS

The preferred method of clearing a bridged crusher is by using a hydraulic arm.

The hydraulic arm may be permanently mounted, or an excavator fitted with a static pick or a hydraulic hammer. Where the arm is operated remotely (eg by radio control) closed circuit television (CCTV) is an invaluable tool in assisting the operator.

Depending on the risk assessment result, clearing out a bridging blockage with a hydraulic arm or similar may be carried out with or without the crusher still operating. Prohibited zones should be established in case of fly-rock.

When hydraulic arms are not available, and it is necessary for a worker to enter the crusher to position hooks or slings, the crusher and feeder must be stopped, isolated and locked-out in accordance with the manufacturer's or supplier's instructions and safe working practices (refer section 17.2).

Other options (which require more specialist expertise and competence) include: gas or chemical expansion and hydraulic ramp plates. Other options considered should be subject to a detailed and thorough risk assessment.

The crusher should be shut off and isolated before considering the use of bars and hand hammers. Bars should never be used on or near a crusher while it is running.

Consider the risk of large pieces of feed material moving and causing trap or crush injuries.

Do not use wedges due to the risk of them becoming a projectile (this has caused fatalities in the past).

### STALLED CRUSHERS

A stalled crusher should be treated as possibly being jammed with tramp metal or wood, which could be ejected with fatal consequences. Safe systems of work should be issued to plant operators detailing what to do in the event of a crusher stalling which should include:

> clearing the area of all workers
> notifying the site manager of the stalled crusher
> isolating power to the crusher and associated plant
> undertaking risk assessment for clearing the blockage
> implementing hazard controls.

### CLEARING BLOCKED CONE CRUSHERS

Many cone crushers are fitted (or can be retrofitted) with tramp metal hydraulic release systems or hydraulic assisted upper concave removal, to prevent or eliminate hazards associated with blocked cone crushers.

For cone crushers that do not have these systems, follow the guidelines in sections 17.5.2.1 and 17.5.2.2 above.

### HAZARD OF ENTRAPMENT AT HOPPERS

There is the potential for an accident if anyone attempts to walk on the material that has been dumped into a hopper. The hazards are that they may be drawn into the feeding material, or, if the material is hung up, they may be drawn in when the material breaks free. The material in the hopper may look solid, but there may be a hidden void where it has bridged over the feeder. Anyone walking on the material is at risk of being engulfed if the bridged-over material collapses.

Mechanical devices should be provided (eg vibrators or air cannons) during normal operations so people are not required to enter or work where they are exposed to entrapment by the caving or sliding of materials. Where people are required to enter or work near the hopper:

> provide platforms or staging
> stop supply and discharge of material
> lock and tag out equipment
> implement working at height procedures as required.

PART D

# 18/

## EMERGENCY MANAGEMENT

### IN THIS SECTION:

18.1 What is an emergency, and what are my duties?

18.2 Keep it simple, and proportionate to the size of the operation

18.3 All emergency management plans should be based on the coordinated incident management system

18.4 Assess potential emergencies

18.5 Identify needs, and confirm capability requirements

18.6 Make the plan

18.7 Test, practise and review the plan

**An emergency occurs when there is an unexpected event that requires urgent action to protect the health, safety and wellbeing of workers or other people. Every operation, whether covered by the Regulations or the Act must have an emergency plan.**

This section describes:

> the process for developing an emergency plan

> the key questions to answer in emergency planning

> how to respond to an emergency

> what to do after the emergency plan is developed.

## 18.1 WHAT IS AN EMERGENCY, AND WHAT ARE MY DUTIES?

An emergency is an unplanned or unexpected event that requires immediate action to protect the health, safety and wellbeing of people. Emergencies occur when controls to hazards fail, putting workers or other people at an immediate risk of harm. Reestablishment of controls, or use of emergency management controls, is urgently required before somebody is harmed. Section 6 (e) of the Act requires employers to develop procedures for dealing with emergencies that may arise while employees are at work.

Part 4, subpart 4 of the Regulations states that where one or more principal hazards are identified, operations must have an Emergency Management Principal Control Plan. A principal hazard is defined in Regulation 65 of the Regulations as:

(a) any hazard arising at any mining operation that could create a risk of multiple fatalities in a single accident or a series of recurring accidents at the mining operation in relation to any of the following:

(i) ground or strata instability

(ii) inundation and inrush of any substance

(iii) mine shafts and winding systems

(iv) roads and other vehicle operating areas

(v) tips, ponds, and voids

(vi) air quality

(vii) fire or explosion

(viii) explosives

(ix) gas outbursts

(x) spontaneous combustion in underground coal mining operations; and

(b) any other hazard at the mining operation that has been identified by the site senior executive under regulation 66 as a hazard that could create a risk of multiple fatalities in a single accident, or a series of recurring accidents at the mining operation.

Operations that identify principal hazards should follow the Regulations.

For lone workers, Section 17 of the Act places a duty on self-employed people to ensure that no action or inaction of the self-employed person while at work harms the self-employed person or any other person. Where there is potential for an emergency, this should include the development of an emergency plan.

When developing an emergency plan, the work should be undertaken with a realistic view that an emergency will likely occur in the near or distant future. Every site must plan for these events. A good emergency plan should be developed using a risk based process. Following the process below will enable operations to answer the right questions in order to develop a plan that is relevant to their specific operation:

| ASSESS POTENTIAL EMERGENCIES | |
|---|---|
| What events could occur at the operation or close by that would require immediate action to protect the health, safety and wellbeing of workers or other people? | How can the operation respond to each identified emergency? |

| MAKE THE PLAN | | | | |
|---|---|---|---|---|
| What elements of an emergency response can be planned in advance? | Who should be consulted when developing the plan? | How will relevant parts of the plan be made accessible to workers in the event of an emergency? | How can the operation's infrastructure be prepared in advance for an emergency response? | How can advanced planning be relayed to workers within the operation? |

| IDENTIFY NEEDS AND CONFIRM CAPABILITY REQUIREMENTS | | |
|---|---|---|
| What resources will the operation need to respond to the identified emergencies? | What training is needed for workers for general emergency response purposes, and what extra training is needed for designated personnel to competently undertake their duties? | What actions or positions will require a designated role or position in an emergency? |

| TEST, PRACTICE, AND REVIEW THE PLAN | | | | |
|---|---|---|---|---|
| How will the emergency plan be tested for effectiveness? | How often will exercises occur? | What types of exercises will the operation need to conduct? | How will areas for improvement be identified? | Who will review or audit the emergency plan and how often will this happen? |

Table 9: Developing an emergency plan

## 18.2 KEEP IT SIMPLE, AND PROPORTIONATE TO THE SIZE OF THE OPERATION

In order for an emergency plan to be effective, it should be kept as simple as possible, and proportionate to the size and scope of the operation. Larger operations and operations that carry principal hazards will require more complex plans, more trained personnel and more on site equipment than small operations or lone workers. Regardless of the size of the plan or the operation, the actions for workers to take in an emergency should be accessible and easy to follow.

In small operations, having the basics of emergency management in place should be sufficient. In larger operations and operations with principal hazards, there will be a greater need for a larger emergency plan.

However large or small, an emergency plan should be accessible, and understood by the workers that must activate it, or follow it in an emergency. This can be done by developing procedures for actions that should be taken in an emergency, and keeping them in a single place, visible to all workers and emergency services. It can be helpful to include workers who have had experience in emergency work as they can help identify emergencies and the response procedures needed.

### 18.2.1 LONE WORKERS AND SMALL OPERATIONS

Small operations and lone workers/operators have different needs to larger operations as there are not enough workers on site to manage an emergency in the same manner as larger operations. Taking the following actions could be sufficient:

1. notifying emergency services of location and entry point to site
2. providing GPS coordinates to emergency services and New Zealand Mines Rescue Service
3. providing adequate means of communication
4. maintaining up to date first aid certificates and providing adequate first aid material including bandages, splints, blankets and cage stretcher
5. setting out a suitable place to land a helicopter
6. providing a list of essential phone numbers to request assistance.

Lone workers should be aware that nobody will be on site to summon emergency services in the event they become injured or trapped. Where there is no service for mobile phones, personal locator beacons could be carried when working on site to be activated in the event of an emergency. This will enable distress signal to be received by emergency services.

It should be noted however, that it will take longer for emergency services to arrive on site when using a personal locator beacon, so good hazard management is critical.

The operator at this operation, a lone worker, has an emergency station set up with first aid kit and buoyancy aid (refer Figure 102). It is visible to emergency services on entry to the site and contains the equipment necessary for immediate response to surrounding hazards that is not kept inside the digger cab. This operator also carries a personal locator beacon with him to communicate in the event of an emergency. For the size and scope of this operation, the emergency station is “fit for purpose”.

**Figure 102:** Example emergency station Photo supplied by New Zealand Petroleum and Minerals

## 18.3 ALL EMERGENCY MANAGEMENT PLANS SHOULD BE BASED ON THE COORDINATED INCIDENT MANAGEMENT SYSTEM

Sometimes, emergencies can escalate from a minor, site level incident to a large multi-agency emergency response. At other times, the incident may be so serious that a large multi-agency response is required immediately. A large response uses the Coordinated Incident Management System (CIMS). This system is best supported when operators base their entire emergency management plan on this system.

#### 18.3.1 WHAT IS CIMS?

CIMS is an emergency response system that describes:

> how New Zealand agencies coordinate, command, and control their response to an incident of any scale
> how the response can be structured
> the relationships between the respective CIMS functions and
> the relationships between the levels of response.

CIMS can expand or shrink to fit any type of emergency. However, it is easier for CIMS to support large scale emergencies when the fundamental principles are used in the emergency management plan. A copy of the CIMS Green Book, which details the principles of CIMS, can be obtained from the Ministry of Civil Defence and Emergency Management website – www.civildefence.govt.nz

### 18.4 ASSESS POTENTIAL EMERGENCIES

Section 7 of the Act places a duty on employers to ensure there are effective methods in place for the systematic identification of hazards, whether new or existing, and assessment to determine whether they are significant hazards. All operators should take the same approach, set out in the Regulations. This is because this systematic process is the correct method in order for all duty holders to discharge their obligations.

Lone workers/operators should also follow the process laid out in the Regulations as good practice.

#### 18.4.1 WHAT HAS THE POTENTIAL TO CAUSE HARM AT THE OPERATION?

Regulation 54 states that a risk appraisal must be undertaken in order to identify hazards. This is commonly known as a broad brush risk assessment. A good risk appraisal should uncover all hazards on the site and in close proximity. Operators should look not only at the hazards on site, but also in the surrounding environment. For example, if an operation was situated in a bushy area, there may be a risk of a forest fire, or flooding if the operation is close to a river. Operators should also look at other risk assessments and incident investigations that have been completed.

#### 18.4.2 WHAT'S THE WORST THAT CAN HAPPEN?

Following a "risk appraisal", Regulation 55 states that the hazards identified in the risk appraisal should be assessed to determine the inherent risk of harm. This means that operators should be asking themselves what the worst case scenario could be when assessing each hazard. Following identification of the worst case scenario, operators should determine how that may affect workers or other people in the vicinity of the operation and how they may need to respond to prevent or minimise damage. If the controls for the hazard fail, and urgent action is required to protect the health, safety and wellbeing of workers or other people, an emergency plan for that hazard is required.

Greater focus should be placed on hazards that have the potential to result in a fatality, or a permanent injury. However an even greater level of focus should be placed on principal hazards that have been identified by way of developing a Principal Hazard Management Plan for each principal hazard. In the event that principal hazards have been identified, an Emergency Management Principal Control Plan should be developed in accordance with Regulations 104 and 105. See the Approved Code of Practice for Emergency Readiness in Mining Operations for further information on developing Emergency Management Principal Control Plans.

Once potential emergencies have been identified, they should be assessed for the most practical response, having regard to the resource and capability within the operation, as well as the size of the operation.

## 18.5 IDENTIFY NEEDS, AND CONFIRM CAPABILITY REQUIREMENTS

Following the risk appraisal and risk assessment, in which potential emergencies and responses have been identified, operators should assess what they need to do in order to make the identified responses viable. This includes identifying the necessary equipment and infrastructure, what certain people or positions will be required to do in the case of each emergency and ensuring they are trained to be able to carry out those duties.

### 18.5.1 WHAT RESOURCES WILL THE OPERATION NEED TO RESPOND TO EMERGENCIES?

Resources include:

- the equipment that will be required in order to respond to emergencies, such as fire extinguishers
- the written material that should be provided to workers, such as procedures and duty cards
- the people that will be required including emergency services
- for operations with principal hazards, the infrastructure that will be necessary to carry out a full scale, multi-agency response.

### 18.5.2 WHAT ACTIONS OR POSITIONS WILL REQUIRE A DESIGNATED ROLE OR POSITION IN AN EMERGENCY?

The most commonly identified role for an emergency is that of a “first aid” provider, such as a “first aider” in smaller operations, or a more highly qualified medic in larger operations. All operators, regardless of the size or the hazards they carry, should have one of these. In small operations, this could be a person with a workplace first aid certificate. In some of the larger operations, there can be paramedics or workers trained in pre hospital emergency care.

Some operations will need people who are trained to extinguish fires. These could be workers who are operating in areas with a high risk of fire, or other workers who can extinguish the fire while the worker from that area escapes safely.

A worker may also be needed to ensure all workers are evacuated from the area of danger by accounting for people.

Operators should consider designating appropriate workers to communicate with families, to secure the site to prevent public access, and to communicate with emergency services until their arrival. In the event of large scale emergencies, where the emergency services are a significant distance from the operation, incident controllers, and other experts may be required to commence a CIMS based emergency operation ahead of their arrival.

### 18.5.3 WHAT TRAINING IS NEEDED FOR WORKERS FOR GENERAL EMERGENCY RESPONSE PURPOSES, AND WHAT EXTRA TRAINING IS NEEDED FOR DESIGNATED PERSONNEL TO COMPETENTLY CARRY OUT THEIR DUTIES?

Having assessed what resource and positions are required, the next step is to ensure the appropriate workers are trained in the use of the equipment and how to competently fulfil their roles. This is a critical element to ensuring the success of an emergency plan.

A good rule to follow is that any knowledge required for an emergency that is not ordinarily a part of a workers day, will need to be provided in the form of training. For example, a first aider will need to be trained in first aid. A person working in an area where there are fire extinguishers provided for a first response will need to be trained in their use. An incident controller or other specialist providing advice to emergency services will need CIMS training. Lone workers may also require training in effective use of personal locator beacons.

Other training may be required in an informal setting, such as training workers on how to quickly and effectively secure the site, and who they should allow to come on site in the event of an emergency. Another form of informal training is how to raise the alarm when there is an emergency, and what information needs to be provided to emergency services during a 111 call.

## 18.6 MAKE THE PLAN

Once the key elements of the emergency plan have been developed during the risk, capability and resource assessments, they will need to be brought together with further information in a formal emergency management plan.

### 18.6.1 WHO SHOULD BE CONSULTED WHEN DEVELOPING THE PLAN?

Workers should always be consulted when developing an emergency plan. As an emergency plan is a part of the wider health and safety management system, operators are obligated under section 19B of the Act to consult with workers. This is an important step as front line workers often have good knowledge of hazards. Their point of view may inform the development of the plan.

Regulation 104 of the Regulations states that emergency services must be consulted. With regard to surface operations, emergency services to be consulted are the New Zealand Fire Service, the New Zealand Police, and the ambulance provider for the region in which the operation is situated. Operators should also consult New Zealand Mines Rescue Service as a matter of good practice.

Consulting with emergency services can assist with planning in advance. For example, emergency services will be made aware of the presence of the operation in the area, its hazards, its capability, its GPS location and Police will likely wish to know what mobile phone coverage is available. If there is none, Police will then know they will need to bring in a mobile cell tower in the event of a large scale emergency. In having consulted with emergency services, a significant amount of planning in advance has already been done. Emergency services can also offer advice for further planning that should be undertaken.

### 18.6.2 WHAT ELEMENTS OF AN EMERGENCY RESPONSE CAN BE PLANNED IN ADVANCE?

If something can happen during an emergency that can be anticipated and planned for, the plan should be made. The only aspects of emergency that cannot be planned for are the unexpected events that happen at the time. There are very few aspects of an emergency that cannot be planned for. Regulation 105 (1) provides minimum requirements for what must be addressed in an Emergency Management Principal Control Plan:

**The coordination and control of emergencies.** The plan should set out the incident control arrangements which should be as simple as possible. There should be a single person in overall charge of operations – this will normally be the manager but other arrangements may also be possible and should be considered. The plan needs to provide for who will be assigned roles if people are not available. Also consider what other resources may be needed in order to effectively manage emergency situations. This plan should be able to support CIMS principles in case a larger response is required.

**The people (or positions) at the site who will have responsibilities in relation to emergencies and the detail of those responsibilities.** These will vary with the circumstances of the site and the results of the risk assessment. These functions may include, but are not limited to:

> coordinating the emergency response, alerting and liaising with rescue or emergency personnel, and regulator personnel (eg Specialist Health and Safety Inspectors, from WorkSafe, regional council staff, district council staff)
> accounting for people at the site at the time of the incident and
> control of emergency supplies
> provision and maintenance of facilities for rescue personnel where required and providing plans and other information to rescue personnel as required
> providing transport of casualties, rescue workers and supplies where required
> operation of communication systems
> informing and consulting with worker representatives and next of kin where required
> communication with the media where required
> fire wardens and site emergency response teams.

**The availability of the Mines Rescue Trust and other emergency services to respond to an emergency: Operations should consider the distance emergency services will need to travel and the time it will take them to respond in an emergency.** A procedure to ensure prompt notification of all relevant emergency services and the Mines Rescue Trust Plans should list the details of all relevant emergency services, the mine rescue trust and any other specialist emergency response personnel. Details should include phone numbers and where relevant, roles within an organisation. Names are only appropriate where there is some certainty the most up to date information is always available.

**The events that trigger the activation of the plan.** These events come from the identification and assessment of potential emergencies. Examples of events that would trigger the activation of the emergency plan could include: vehicle collision, rock fall, the presence of smoke or fire, or a medical emergency. One of the more obvious and well known ‘activation triggers’ is upon hearing a worker shout “emergency, emergency, emergency!”.

The plan should be immediately activated and workers should be trained, and empowered to do so with confidence. It is easy to deescalate a large emergency once further information comes to hand, but it is impossible to bring back the ten to fifteen minutes of lost time that can ultimately save lives. Therefore, it is better to have a false alarm than a slow start, or no alarm at all.

**The use of communication systems in emergencies.** Determine how and what communication systems are used in an emergency. This can include:

> clearing radio channels,
> ending all non-essential phone calls,
> communication black-outs,
> the availability of additional communication devices (eg satellite phones and the communication systems of the Police).

Good communications are of paramount importance in an emergency, particularly in remote areas and for lone workers. Suitable communication equipment might range from alarms to more sophisticated public address or closed-circuit television systems. Radios or telephones can enable rapid communication if they are carefully positioned. They may, for example, be fitted to mobile plant or backup service vehicles, or issued to appropriate individuals. Electrical systems, radios or mobile telephones may be unsuitable where explosives are in use, or where there is a risk of an explosive atmosphere.

**The giving of timely notice, information and warnings to anyone potentially affected, including the people nominated as next of kin by workers.** Consider:

> Developing a call tree so the right people are notified at the right time.

> Determining how and when next of kin will be notified. This may be dependent on the severity of casualties and the location of the next of kin. Notification could be via support services (Police).

> Determining how and when neighbouring properties will be contacted.

> Determining how and when status updates will be communicated.

As a part of the general health and safety management system, emergency contact details for all workers should be prepared and kept up to date through regular reviews.

**Measures to be taken to isolate an area affected by an emergency.** Measures will be dependent on the type of emergency. Some examples include barriers to block access to unsafe areas or posting sentries at the gate to stop vehicles entering an area. Others may include pre-planning the development of fire breaks to prevent fires from spreading into surrounding areas during an emergency.

**The means to locate and account for people in the event of an emergency.** Operators should have a system in place to accurately account for and locate all workers or visitors in the event of an emergency. This is good practise for all quarry and alluvial mine operators, and a legal requirement for other mine operators as defined in section 19M of the Health and Safety in Employment (Mining Operations and Quarrying Operations) Regulations 2013.' Sign in registers, worker tag boards or radio frequency identification (RFID) tags are some of the ways operators could locate and account for people. A suitable system will depend on the size of the operation or site, the number of workers, the frequency of visitors, working times and shifts, and the risks that may be present.

**Evacuation in an emergency, including the conditions that will prompt withdrawal when there is an imminent risk of harm.** Operators should determine what responses are necessary to ensure all people escape safely and when evacuation is necessary. Evacuation may include first response, self-escape, aided escape or aided rescue. For example a person in a confined space may be able to self-escape or may require aided rescue. Prompt withdrawal, for example, may include where smoke alarms are activated, when ground movement has been detected, or when weather warnings are issued. Operators should also determine the hazards produced as a result of the emergency that workers self-escaping and self-rescuing may face and what responses are necessary to affect their escape or rescue.

**Appropriate transportation from the site.** You should include in your plan the provision and method for removing all people on site to a designated suitable, safe area. This may include visitors and members of the public. Note that walking is a limited option as this plan should include the transport of casualties.

**First aid arrangements including first-aid equipment, facilities, services and the workers who are qualified to provide first aid.** Measures will be dependent on the type of incident and the availability and response times of emergency services. One way to identify the first aid needs of the site is to complete a Workplace First Aid Needs Assessment. WorkSafe's *First Aid for Workplaces, A Good Practice Guide* has a sample assessment. An example of some of the equipment that may be needed is when providing first aid to casualties in large vehicles. It can be difficult to remove casualties from height and if attempts are made to remove them from the vehicles prior to treating them, this can cause significant delays in providing treatment and in some cases, lower the likely survival rate. Having a detachable basket that can be attached to mobile plant for the provision of first aid to drivers of large earthmoving equipment and other mobile plant may be an effective option.

**Provision for all aspects of firefighting, including adequate compatible firefighting equipment, procedures for firefighting and training workers in firefighting.** Firefighting equipment should be strategically positioned and be of a suitable type for the potential fires that could occur. For example a fire extinguisher capable of fighting fuel fires should be positioned in all vehicles.

PHMPs are required to include a description of the emergency preparedness for the principal hazard. It is recommended all relevant information is recorded in the Emergency Management Principal Control Plan, with a reference in the PHMP, to ensure only the most up to date information is followed in the event of an emergency.

Further to the minimum requirements in Regulation 105 (1), all parts of the emergency plan that require a worker to take action should have a corresponding procedure indicating the steps and actions that must be taken.

While operations covered by this guidance may not fall under the Regulations, this is the minimum that all operations should address in their emergency plan, as a matter of good practise. Smaller operations and lone workers may be unable to fulfil all of these requirements. The requirements laid down in 18.2.1 as a minimum are sufficient for these operations.

Suitable equipment to respond to identified emergencies should be made available for use, so that the plan can be successfully implemented in the event of an emergency. The choice of emergency equipment will depend on the emergencies that have been identified, the complexity of the site, and the distance from emergency services. Examples of the type of rescue and emergency equipment which may be required include:

- breathing apparatus (for confined space entry)
- ropes
- ladders (rigid or rope)
- tripods, winches
- tools (ie pickaxe, crowbar, shovel, cutters)
- stretchers and blankets
- buoyancy aids (ie lifejackets or lifebuoys)
- rescue boats
- chemical spill kit
- fire extinguishers
- fire hose reels
- bush fire kits
- first aid supplies
- self-rescuers
- a mobile generator to power emergency lighting
- lifting and cutting equipment such as hydraulic props, hardwood wedges in various sizes, lifting bags and cylinders, pneumatic pick
- resuscitation equipment
- defibrillator

> detachable personnel basket for large earthmoving equipment
> lifting hoops
> a sanitary area designated for the provision of first aid, such as a first aid room.

Rescue and emergency equipment should be subject to appropriate inspection to make sure it is always ready for use. Where rescue equipment is provided, enough people should be trained to use it without endangering themselves or others. Training in rescue equipment should be specific to the type of emergency (eg confined space rescue, heights rescue, use of a fire extinguisher).

Regulation 125 states that Mine Operators must ensure there are adequate and appropriate means available at the site to deal with any crush injuries and to rescue a trapped or injured person. Regulation 127 states Mine Operators must ensure that suitable resuscitation equipment is available and people trained to use the equipment are available at the site at all times. A procedure must be in place for workers to raise the alarm when resuscitation equipment is required. Larger operations that use more advanced medical personnel should consult them as to the most suitable equipment, and whether they are trained to use it. If not, training should be provided.

Means of escape should be taken into account when designing both fixed and mobile workplaces. An alternative exit should always be provided in mobile equipment. These can be purpose built hatches or windows that can be easily removed or broken with a special tool. Fire extinguishers should also be provided on equipment where there is a risk of fire.

Well-constructed and maintained roadways allow emergency vehicles easier access. These vehicles are generally made for road use and are not suited to difficult terrain. In an emergency, it can be helpful to have a person waiting at the site entrance to direct the emergency services. Where there is a risk of fire, there should be enough room for at least three fire appliances and several other emergency vehicles to park.

In remote areas it may be faster for emergency services to respond with a helicopter. An area for a helicopter to land should be planned for and passed to emergency services during consultation.

**Important: Don't forget the back-up plan.** Sometimes the best procedures fail and it is important to have a back-up plan in the event that this happens. A good example of this is fires on mobile plant such as large trucks. These are known to carry an elevated risk of fire, so many operations use a built in fire suppression system. However, these do not always properly extinguish the fire, so a fire extinguisher is usually provided to finish the job. In the event that the fire extinguisher does not work, there is a procedure in place to withdraw workers and other people from the area and let the fire burn out. When developing procedures, operators should always ask the question "if it fails, then what?"

### 18.6.3 HOW WILL RELEVANT PARTS OF THE PLAN BE MADE ACCESSIBLE TO WORKERS IN THE EVENT OF AN EMERGENCY?

Emergency response and evacuation plans are normally designed as a "grab and go" procedure detailing specific actions to be taken in emergency scenarios. Emergency response and evacuation plans may also include signage and bullet point procedures placed in appropriate areas, such as doorways or close to areas where immediate response is required. These should be kept as simple as possible, and should contain checklists of tasks in the order in which they should be carried out. They should also be accessible to the workers who have to use them. This can be done by designating a specific area as an emergency area where all emergency procedures and rescue equipment are kept (aside from equipment that is fixed in specific areas for immediate response). And keeping duplicates close to the areas where immediate response will be required.

For larger operations the use of TARPs may be appropriate.

For smaller operations an emergency response plan flipchart (a set of simple forms that can help you identify and manage your emergency procedures) is available from the Environmental Protection Authority (EPA). Phone 0800 376 234 or email hsinfo@epa.govt.nz to order a free copy or download a pdf version from www.business.govt.nz/worksafe/information-guidance/all-guidance-items/emergency-procedures.

Most workers may only need to be able to leave their workplace and go to a designated place of safety in the event of an emergency. Section 12 (1) (a) of the HSE Act states employers must inform workers on what to do if an emergency arises. This should be an integral part of training at all operations, and should be included in site inductions for workers and other people.

The SSE must, and alluvial mine and quarry operators should, ensure emergency management control plans are regularly tested using practice drills and involving relevant emergency services (eg the Fire Service, St John's, Mines Rescue Trust and company rescue services). Regular testing should be at least every three months. More regular testing may be needed, as identified through the assessment processes.

### 18.6.4 HOW CAN THE MINING OPERATION'S INFRASTRUCTURE BE PREPARED IN ADVANCE FOR AN EMERGENCY RESPONSE?

Preparing the site is merely an extension of section 18.5.2 where it is stated that if it can be planned for, the plan should be made.

All procedures that have been developed and the equipment required for emergency response should be placed in an area that is easy for all workers on the site and emergency services entering the site to find. This could become a designated emergency station. Fire extinguishers should be placed where they will be needed, for example inside trucks and on barges.

Further copies of response procedures should be placed close to the area in which they will be needed.

When consulting with Police, they may advise what preparation they would like to see undertaken for a large scale emergency response. Ideally this would be a room for around 15 people with good communication systems and a lot of whiteboard space. This is called the incident control point. However in small operations, not all sites will have infrastructure that enables this. Advice given from Police should be taken in these situations.

Further site preparations should be marked out on a site map that shows the safe forward point, inner and outer perimeters of the operation. The outer perimeter basically marks out the site. The inner perimeter marks out the area that is particularly hazardous, that only the rescue/recovery team should cross.

A staging area where emergency services can muster and be briefed should also be marked out. This should be between the inner and outer perimeters, and not so close to the incident control point as to disrupt the incident management team.

In larger operations, first aid equipment should be strategically placed on the site to ensure it is easily accessible. All emergency equipment should be marked out on a map of the site and adequate signage to indicate where specific equipment is kept (such as the defibrillator if one will be made available) should be placed around the site.

Figure 103 shows a common incident at quarrying, mining and alluvial mining operations. Operators should determine the worst case scenario resulting from an emergency of this nature and develop their response plans around minimising harm from there.

**Figure 103:** Vehicle overturn emergency

## 18.7 TEST, PRACTISE AND REVIEW THE PLAN

An emergency management plan cannot be said to be effective until every component of the plan is tested in a practical sense. This can be done using a series of exercises, which also assists with ensuring the plan is regularly practised, however the plan should be practised regularly once it is said to be effective. When the plan has been tested and practised, or when new hazards arise on site, the plan should be reviewed. It should also be audited on an annual basis to ensure it has been reviewed at times it should have. The plan should also be reviewed following any emergency that occurs on the site.

### 18.7.1 HOW WILL THE EMERGENCY PLAN BE TESTED FOR EFFECTIVENESS?

Regulation 106 states that the emergency plan must be tested regularly using practice drills, and involving emergency services. This enables the emergency services to provide advice on any gaps in training or in the plan that may need to be filled. It also tests the effectiveness of the plan.

Every component should be tested for effectiveness. For larger operations, this means that there should be an exercise that involves the notification of families, accounting for people in the operation and notifying all managers on or off site of the emergency. If there are any areas of the plan that are deemed ineffective, the appropriate amendments should be made and tested again in the next exercise.

Testing should be carried out using realistic scenarios based on the hazards identified and planned for, with further events if it could reasonably be expected that further issues will arise during an emergency.

### 18.7.2 HOW OFTEN WILL EXERCISES OCCUR AND WHAT TYPES OF EXERCISES WILL THE OPERATION NEED TO CONDUCT?

Regulation 106 (1) (b) of the Regulations states that the SSE must ensure workers are provided with training in the emergency management control plan and that the provision of this training is recorded. This is an important aspect of emergency planning in any operation.

Practice drills are essential so everyone knows what to do in an emergency. This includes contractors employed at the site. In the case of contractors employed on short contracts, visitor training may be more appropriate. Such contractors should be accompanied at all times by a person who has appropriate emergency training.

Exercises should happen at minimum, on a quarterly basis in order to develop a "second nature" response in workers on the site. Exercises should be both anticipated for the purpose of training, and conducted without the prior knowledge of workers for the purpose of experience. Don't forget to add variety into exercises, so that all aspects of the emergency plan can be tested.

The most likely scenarios, and life preserving, escape and rescue scenarios should be exercised more frequently. Where a worker may be required to take action to save their own life or others, this should be a key area of concentration. Other aspects of the emergency plan should be exercised regularly, but not at the expense of the lifesaving components.

The aspects of an emergency plan that will always be used, such as contacting all managers both on and off the site, and accounting for people, should be practised during all exercises.

### 18.7.3 HOW WILL AREAS FOR IMPROVEMENT BE IDENTIFIED?

Nobody has a "perfect plan". Gaps will always be identified in emergencies. Gaps and areas for improvement can be identified using post-exercise debriefs where workers and managers can all state what they saw going well, and what didn't go so well. Observers from emergency services can also be used to provide advice. One of the key factors in identifying areas for improvement is not to jump to blaming the worker when something goes wrong.

Often, it can be a case of the procedure not being written simply enough, or equipment being unavailable, or in the wrong place. Training can also be a factor. Identifying these issues will enable the plan to be reviewed with a view to improving it for retesting at a later stage.

### 18.7.4 WHO WILL REVIEW OR AUDIT THE EMERGENCY PLAN AND HOW OFTEN WILL THIS HAPPEN?

All plans need to be reviewed and audited on a regular basis. Each emergency management plan should contain a section identifying the person or position that will audit the plan, to ensure it is compliant, it addresses all potential emergencies on the site and it is practical. This should be done on a set basis, such as annually. This should be the person with the highest statutory position on site, such as the quarry manager or the SSE.

Each emergency plan should be reviewed after each exercise, when new hazards are identified. In accordance with Regulation 94, emergency plans must also be reviewed after real emergencies prior to operations recommencing. This should be the person responsible for developing the emergency management plan, in consultation with the person who would normally audit the plan. When there are significant changes to emergency plans, further consultation with emergency services may be required.

Understanding and enacting the emergency plan that has been developed for the operation could save your life and the lives of others.

PART D

# 19/

## WORKER PARTICIPATION

## You must provide opportunities for workers to participate effectively in ongoing processes to improve health and safety. Use a worker participation system to manage this process.

This section describes:

> the legal requirements for worker participation
> good-practice guidelines for putting an effective system in place.

Reasonable opportunities must be provided for employees to participate effectively in improving health and safety at work. For a mining operation (opencast mines) this includes all mine workers, not just employees. The worker participation system must be a documented system.

The HSE Act does not require you to adopt a particular system. In fact, there is a clear expectation that you and your workforce (and unions representing any employees), will, in good faith, work out the systems and processes that best suit the workplace's particular circumstances. This collaboration should provide the best opportunities for workers to participate effectively in health and safety.

For mining operations, where a worker participation system is not in place within the prescribed time periods in section 19U of the HSE Act, the default system of Schedule 3 of the Regulations applies.

If one or more mine workers request a health and safety representative, at least one must be included as part of the worker participation system.

For quarries and alluvial mines, a worker participation system must be developed if there are 30 or more employees, or an employee (or a union) requests one be developed. Where agreement cannot be made on an employee participation system, the default system set out in section 19D and Schedule 1A of the HSE Act applies.

The default system requires that an election for a health and safety representative is held.

WorkSafe considers it good practice to:

> implement a documented system for worker participation based on good faith and a clear commitment to health and safety outcomes
> have at least one health and safety committee for every location or site and that each committee focus on safety critical aspects of the mining or quarrying operation
> have effective, empowered and informed site health and safety representatives that are trained under the HSE Act.

If a site health and safety representative or committee makes a health and safety recommendation to the employer it must be adopted or a written statement provided setting out the reasons for not adopting it.

PART D

# 20/

# TRAINING AND SUPERVISION

## IN THIS SECTION:


20.1 Identify skills, knowledge or competencies

20.2 Induction training

20.3 Training workers

20.4 Supervision

20.5 Use of contractors

20.6 Training Records

## Everyone working at the site must be competent for the work they are required to do, or be supervised by competent workers. They, and their managers, need to know the limits of their competence.

This section describes how to:

> identify the skills, knowledge or competencies your workers need
> train workers when they start work and when they need to learn new skills
> keep records to prove what training you have provided.

You must train or supervise workers so they can do their work safely.

The employer or person in control of the workplace must tell workers about the hazards of the work and what they need to do to stay safe.

Training helps people share knowledge and develop skills. It can help influence behaviours and improve health and safety.

A training programme should:

> identify what skills, knowledge or competencies workers need to do particular tasks
> have an induction – to show new workers around the site and tell them about hazards and safety procedures
> provide ways to train workers – for example, use external training providers or do on the job instruction
> make sure people only do work if they're trained or properly supervised
> keep records of workers training and instruction, and identify which job they can and can't do.

People might need extra training for some processes and machinery.

This guidance does not cover formal qualifications required by the Regulations. This provides more detailed information on the role or management, and requirements in relation to roles, responsibilities and competencies of people employed at mines, quarries or alluvial mines.

### 20.1 IDENTIFY SKILLS, KNOWLEDGE OR COMPETENCIES

There are a number of ways in which you can determine the competencies needed for particular jobs. These include:

> risk assessments and hazard identification processes
> personal performance reviews
> health and safety audits or inspections
> analysis of accident investigations and near-miss reports
> competencies specified by vehicle or equipment manufacturers
> national qualifications framework
> recommendations in Codes of Practice, Guidelines or Standards
> those required by the law.

By comparing the competencies needed with those which people already have, managers can determine what additional skills are required and how these can be achieved, for example through training and coaching.

## 20.2 INDUCTION TRAINING

Give suitable induction training to everyone who is new to a site, or has been absent for an extended period of time. This is particularly important for those who are new to the industry.

Induction should be job and site-specific. Induction should include relevant aspects of your health and safety policy, the health and safety management system, risk assessments, the arrangements for first aid, fire, evacuation, safe systems of work and so on.

## 20.3 TRAINING WORKERS

Education and training can be in-house or a formal programme. The aim is make sure each person and the team as a whole can operate safely.

When they have finished training, get them to explain and demonstrate their understanding. Even if a new worker has excellent qualifications and experience, always assess their competence to work on your site.

Further training is likely to be needed whenever:

> someone takes on substantial new responsibilities

> there is a significant change in work equipment or systems of work.

Skills decline if they are not used regularly and refresher training should be provided as necessary to make sure continued competence in skills that are not often used (ie confined space training).

It can be useful to involve experienced workers in training as they are often best placed to understand the risks involved in their work. Take care, however, to ensure bad habits are not passed on.

## 20.4 SUPERVISION

You must have a skilled worker closely supervise new or untrained workers until they can work safely.

Mine workers who do not require a certificate of competence or who have not achieved unit standards specified by WorkSafe must be accompanied (supervised) at all times by a mine worker who has achieved the unit standards, or has received equivalent training, or holds a certificate of competence, and has at least 12 months experience working at the same kind of mining operation[92].

## 20.5 USE OF CONTRACTORS

Mines or quarries may use contractors to undertake some or all of the activities on site. The requirement to provide training and supervision and ensure competency to use plant and equipment applies equally to both in-house and contracted workers. You must fully induct contractors on your company's processes and make sure the contractors follow safe working practices.

For more detailed information on the selection and management of contractors see *A Principal's Guide to Contracting to Meet the Health and Safety in Employment Act 1992* and its summary *Health and Safety in Contracting Situations.*

## 20.6 TRAINING RECORDS

You should keep training records as part of your health and safety management system. This could include copies of external training provider certificates, in-house or on-the-job training records, attendance lists and driver's licences.

[92] The Regulations, regulation 50

# 21/

# GLOSSARY

| TERM | DEFINITION |
|---|---|
| **Affected person (for LOTO)** | Is a worker whose job requires them to operate a system, or work in an area in which servicing or maintenance is being performed under LOTO |
| **Alluvial mine operator** | Has the meaning given in regulation 3 of the Regulations |
| **Alluvial mining operation** | Has the meaning given in section 19L of the HSE Act |
| **ANFO** | An explosive material consisting of ammonium nitrate and fuel oil |
| **Angle of repose** | The angle of repose is the angle at which the material rests when simply dumped in a pile. This angle will vary somewhat depending on the size and shape of the constituent particles, how the material is dumped (eg how far it is dropped) and the amount of moisture in the material when it is dumped |
| **Approved Handler** | Has the meaning given in regulation 3 of the Hazardous Substances (Class 1-5) Regulations |
| **Authorised person (for LOTO)** | Is an individual who is qualified to control hazardous energy sources because of their knowledge, training and experience and has been given authority to apply LOTO |
| **Back-break** | Rock broken beyond the limits of the last row of holes in a blast |
| **Batter** | The portion of a slope between benches (see Figure 2 on page 20) |
| **Bench Benching** | A safety feature to catch any rocks or reeling material that falls from the high walls above.<br>A horizontal ledge from which holes are drilled vertically down into the material to be blasted.<br>Benching is a process of excavating where a slope is worked in steps or lifts |
| **Building** | Has the meaning given in sections 8 and 9 of the *Building Act 2004* |
| **Building Code** | *The Building Code* set out in Schedule 1 of the *Building Regulations 1992* |
| **Competent person** | Has the meaning given in regulation 3 of the Regulations and, in general, means a person who has the relevant knowledge, experience, and skill to carry out a task and who has a relevant qualification or certificate |
| **Confined space** | A 'confined space' is a place which is substantially (though not always entirely) enclosed, and where there is a risk of death or serious injury from hazardous substances or dangerous conditions (ie lack of oxygen). These can include storage tanks, silos, reaction vessels, enclosed drains and sewers, open topped chambers, ductwork and poorly ventilated rooms |
| **Contractor** | Has the meaning given in section 2 of the HSE Act and means, in general, a person engaged other than as an employee to undertake work at the site |
| **Control** | An action taken that eliminates, isolates or minimises a hazard |
| **Crest** | The top edge of a slope or batter where the ground levels out |

| TERM | DEFINITION |
| --- | --- |
| **Dam** | Has the meaning given in section 7 of the *Building Act 2004* being<br>“dam—<br>(a) means an artificial barrier, and its appurtenant structures, that—<br>(i) is constructed to hold back water or other fluid under constant pressure so as to form a reservoir; and<br>(ii ) is used for the storage, control, or diversion of water or other fluid; and<br>(b) includes—<br>(i) a flood control dam; and<br>(ii) a natural feature that has been significantly modified to function as a dam; and<br>(iii) a canal; but<br>(c) does not include a stopbank designed to control floodwaters” |
| **De-energisation**<br>**De-energising**<br>**De-energise** | De-energisation is the process used to disconnect and isolate a system from a source of energy in order to prevent the release of that energy. By de-energising the system, you are eliminating the chance the system could inadvertently, accidentally or unintentionally cause harm to a person through movement, or the release of heat, light or sound |
| **Document Control** | The systems by which records are kept, including the allocation of responsibility to specific staff members |
| **Emergency drill** | A process of testing training, relating to emergency events, which is repeated from time to time |
| **Emergency (emergency event, emergencies)** | An unplanned event that is not controlled where there is a threat to life or the health and safety of people at or outside the operation |
| **Employer** | Has the meaning given in section 2 of the HSE Act |
| **Face** | The surface where extraction is advancing. May also be referred to as pit face or working face. |
| **FRAS** | Fire resistant anti-static |
| **Freeboard (for dams)** | The distance between normal reservoir level and the top of the dam |
| **Freeboard (for vessels)** | The distance between the waterline and the main deck or weather deck of a ship or between the level of the water and the upper edge of the side of a small boat |
| **Haul vehicles** | Vehicles used to haul product or material from the place of extraction to the processing plant, stockpile or tip |
| **Hazard** | Has the meaning given in section 2 of the HSE Act |
| **Hazard assessment** | The overall process of analysing and evaluating the hazard |
| **Hazard control** | Refer to control |
| **Hazard management** | The culture, processes and structures that are directed towards the effective management of potential injury, illness, damage or loss |
| **Hazardous substance** | Has the meaning given in HSNO |

| TERM | DEFINITION |
|---|---|
| **Site Health and Safety Representative** | Has the meanings given in section 19L of the HSE Act |
| **Heavy vehicles** | Includes haul trucks, loaders, scrapers, dozers, water trucks, graders, low loaders, cable reelers, draglines, shovels, backhoes, drills and like equipment. Heavy vehicles are those that transport or extract materials, overburden or reject material |
| **HSNO** | Includes both the *Hazardous Substances and New Organisms Act 1996* and regulations made under that Act |
| **Inter-ramp slope** | A succession of batters between two access ramp sections (or between a ramp section and floor or crest) |
| **Intrusive maintenance** | Maintenance that requires interruption to the process. It usually requires shutdown, isolation of hazardous energy, LOTO, opening or disassembly |
| **Large dam** | Has the meaning given in section 7 of the *Building Act 2004* being "large dam means a dam that has a height of 4 or more metres and holds 20 000 or more cubic metres volume of water or other fluid" |
| **Light vehicles** | Includes wheel mounted light and medium duty vehicles of various sizes which are primarily used in the transportation of people, supplies, tools and fuel or lubricants. They include but are not limited to lube trucks, utes, SUVs, vans used as worker transporters, tyre mounted cranes, and forklifts, and so on |
| **LOTO** | Lockout and Tag out |
| **Maritime Rules** | Maritime Rules made under the *Maritime Transport Act 1994* |
| **Mineral** | Has the meaning given in section 19L of the HSE Act being "a naturally occurring inorganic substance beneath or at the surface of the earth, and:<br>a. includes metallic minerals, non-metallic minerals, and precious stones; and<br>b. does not include clay, coal, gravel, limestone, sand or stone" |
| **Mining operation** | Has the meaning given in section 19L of the HSE Act |
| **Mine operator** | Has the meaning given in regulation 3 of the Regulations being:<br>a. has the meaning given in section 19L of the HSE Act; and<br>b. in relation to a particular mining operation, means the mine operator for that mining operation |
| **Misfire** | When a blast does not fire correctly, or one or more blast holes do not fire |
| **Mobile plant (for the purpose of this guidance)** | Means plant that is not a light vehicle, haul truck or water tanker. For example bulldozer, excavator, loader, scraper and so on |
| **Monitor** | To check, supervise, observe or record the progress of an activity or procedure regularly in order to make sure it is being carried out |
| **MOSS** | Maritime Operator Safety System |

| TERM | DEFINITION |
|---|---|
| **Near Miss** | An event that has the potential to cause injury or illness if circumstances, such as the interval of time of the event, were different |
| **Non-intrusive maintenance** | Maintenance tasks that do not require process interruption, machinery or equipment shutdown, LOTO, entry or disassembly |
| **OHS** | Occupational Health and Safety |
| **Opencast coal mining operation** | Has the meaning given in regulation 3 of the Regulations |
| **Opencast metalliferous mining operation** | Has the meaning given in regulation 3 of the Regulations |
| **Overall slope** | The full height of a slope from the toe to the crest which may comprise several batters separated by benches (see Figure 3 on page 31) |
| **Overburden (mines)** | In mining overburden (also called waste or spoil) is the material that lies above an area of economic interest. It is most commonly the rock, soil, and vegetation above a coal seam or ore body |
| **Overburden (quarries)** | In quarrying overburden is the material that lies above the intended quarry site. It is most commonly the top-soil, sub-soil and vegetation |
| **PCP** | Principal Control Plan |
| **Person in charge (in relation to HSNO)** | 'Person in charge' has the meaning given in regulation 3 of the Hazardous Substances (Class 1-5) Regulations being:<br>"In relation to a place, a hazardous substance location, a transit depot, or a place of work, means a person who is:<br>> The owner, lessee, sub-lessee, occupier, or person in possession of the place, or deport, or any part of it; or<br>> Any other person who, at the relevant time, is in effective control or possession of the relevant part of the place, location, or depot" |
| **Personal protective equipment or clothing** | Safety apparel, protective devices and equipment that protect the health and safety of an individual person |
| **PHMP** | Principal Hazard Management Plan |
| **Policy** | Statement by a site (or company) of its commitment, intentions and principles in relation to its overall health and safety performance |
| **Powder factor** | The amount of explosive used per unit of rock. Also called Explosive Loading Factor |
| **PPE** | Personal protective equipment |
| **Pre-start check** | A safety checklist that is undertaken prior to first use of machinery or vehicles for that day or shift |
| **Principal** | Has the meaning in section 2 of the HSE Act – a person who or that engages any person (other than an employee) to do any work for gain or reward |

| TERM | DEFINITION |
|---|---|
| **Principal control plan** | Means a plan required under regulation 92 of the Regulations |
| **Principal hazard** | Has the meaning given in regulation 65 of the Regulations. While alluvial mines and quarries are not legally required to appraise risks to determine principal hazards, for the purposes of this guidance we have described risks where multiple fatalities could occur as a principal hazard |
| **Principal hazard management plan** | Means a plan required under regulation 66 of the Regulations |
| **Procedure** | A set of instructions, rules or a step-by-step description of what's to be done and by whom |
| **Prohibited zone** | Zone or area where people are not allowed such as at the bottom of a working tip face, the loading zone around vehicles |
| **Pyrolysis** | Chemical decomposition of compounds caused by high temperatures |
| **Quarrying operation** | Has the meaning given in section 19N of the HSE Act |
| **Quarry operator** | Has the meaning given in regulation 3 of the Regulations |
| **Restricted area or restricted access** | Area or zone where people or vehicles are not allowed unless certain conditions are met. For example, entry to an electrical switchboard room may be restricted to maintenance personnel under a permit to work; light vehicles may be restricted to entering a vehicle operating area when traffic has been stopped |
| **Review** | Checking to see whether goals have been achieved, and to assess what need to be done in future |
| **Riprap** | A layer of large quarried stone, precast blocks, bags of cement, or other suitable material, generally placed on the slope of an embankment or along a watercourse as protection against wave action, erosion, or scour. Riprap is usually placed by dumping or other mechanical methods, and in some cases is hand placed. It consists of rock pieces of relatively large size, as distinguished from a gravel blanket |
| **Roads** | A road is a constructed travel way between designated locations designed to accommodate the vehicles that operate at a site. It includes all thoroughfares used by heavy or light vehicles, and any roads used by the public within the site boundaries |
| **Safe Work Procedure** | A written instruction that sets out how an activity is to be undertaken at an operation. It can be used for training or observing activities for monitoring or review. Also known as Safe Work Methods Statement, Standard Operating Procedures, Work Method Statement or Task Analysis |
| **SDS** | Safety Data Sheet |
| **Serious harm** | Has the meaning in section 2 of the HSE Act – death or an injury that is defined in Schedule 1 of the HSE Act |
| **Shotfirer** | The competent person in charge of, and responsible for, the loading and firing of a blast |

| TERM | DEFINITION |
|---|---|
| **Site** | A place of work where extractive operations (mining and quarrying) and/or associated activities are carried out |
| **Sleep time** | In relation to explosive use, sleep time is defined as the time between charging and firing the shot |
| **SOP** | Standard operating procedure |
| **Standard operating procedure** | Documented, often step-by-step, processes by which workers can perform each task or aspect of the operation |
| **Stockpile** | Material placed, usually on a temporary basis, that is recovered and replaced |
| **SWL** | See WLL |
| **SWP** | Safe work procedure |
| **Tip** | May include an overburden tip or waste material tip of a permanent nature. Often called waste dumps or waste rock stacks |
| **Toolbox meeting** | Formal or informal meeting held between workers, usually at the place the work is undertaken (around the toolbox) and usually before a shift or a specific job starts. Sometimes referred to as a tailgate meeting |
| **Tourist mining operation** | Has the meaning in section 19L of the HSE Act |
| **Tree-felling** | Has the meaning in regulation 2 of the *Health and Safety in Employment Regulations 1995*. For the purpose of this guidance paragraph (b) (ii) is the aspect of the definition likely to apply. That is "felling trees by manual or mechanical means for the purpose of land clearance" |
| **Vehicle** | Self-propelled equipment or plant used for the carriage of goods, material or people for operational requirements. May include heavy vehicles, light vehicles or mobile plant |
| **Vehicle operating areas** | Other vehicle operating areas are all areas on or at a site where operations involve the use of vehicles other than roads. For example, tip points, stockpiles or loading areas. It includes any vehicle operating areas used by the public within the site boundaries |

<table>
<tr><th>TERM</th><th>DEFINITION</th></tr>
<tr><td>Soils and very weak rock</td><td>As defined by the NZ Geotechnical Society Incorporated Field Description of Soil Analysis Guideline (Dec 2005) Table 3.5 Rock Strength Terms being:
<table>
<tr><th>Term</th><th>Field identification of specimen</th><th>Unconfined uniaxial compressive strength $q_u$ (MPa)</th><th>Point load strength $I_{s(50)}$ (MPa)</th></tr>
<tr><td>Very weak</td><td>Crumbles under firm blows with point of geological hammer. Can be peeled by a pocket knife.</td><td>1 – 5</td><td rowspan="2"><1</td></tr>
<tr><td>Extremely weak (also needs additional description in soil terminology)</td><td>Indented by thumb nail or other lesser strength terms used for soils</td><td><1</td></tr>
<tr><td colspan="4">Note: No correlation is implied between $q_u$ and $I_{s(50)}$</td></tr>
</table></td></tr>
<tr><td>Stronger rock</td><td>As defined by the NZ Geotechnical Society Incorporated Field Description of Soil Analysis Guideline (Dec 2005) Table 3.5 Rock Strength Terms being:
<table>
<tr><th>Term</th><th>Field identification of specimen</th><th>Unconfined uniaxial compressive strength $q_u$ (MPa)</th><th>Point load strength $I_{s(50)}$ (MPa)</th></tr>
<tr><td>Extremely strong</td><td>Can only be chipped with geological hammer</td><td>>250</td><td>>10</td></tr>
<tr><td>Very strong</td><td>Requires many blows of geological hammer to break it</td><td>100 – 250</td><td>5 – 10</td></tr>
<tr><td>Strong</td><td>Requires more than one blow of geological hammer to fracture it</td><td>50 – 100</td><td>2 – 5</td></tr>
<tr><td>Moderately strong</td><td>Cannot be scraped or peeled with a pocket knife. Can be fractured with single firm blow of geological hammer</td><td>20 – 50</td><td>1 – 2</td></tr>
<tr><td>Weak</td><td>Can be peeled by a pocket knife with difficulty. Shallow indentations made by firm blow with point of geological hammer</td><td>5 – 20</td><td><1</td></tr>
<tr><td colspan="4">Note: No correlation is implied between $q_u$ and $I_{s(50)}$</td></tr>
</table></td></tr>
</table>

| TERM | DEFINITION |
|---|---|
| **WLL** | Means the working load limit, the maximum working load designed by the manufacturer. This term is now used instead of SWL (safe working limit) |
| **Work Instruction SOP** | See Standard Operating Procedure |
| **Worker (for the purposes of this guidance)** | A person who works at the site. May include, but not limited to, employer, employees, workers, contractors, sub-contractors, specialists and consultants |
| **Worker participation** | A system for the participation of workers in health and safety matters, as described in Part 2A and Part 2B of the HSE Act |
| **Working bench** | The level on which the excavator is sitting on or the trucks are running on |

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> Jakubec. J. and Esterhuizen, G. S. Use of the mining rock mass rating (MRMR) classification: Industry experience. Sourced from stacks.cdc.gov.

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> Maritime New Zealand *Barge Stability Guidelines.*

> Ministry of Consumer Affairs *New Zealand Electrical Code of Practice for Electrical Safe Distances (NZECP 34:2001).*

> New Zealand Geotechnical Society Inc. *Field Description of Soil and Rock: Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes.*

> New Zealand Transport Agency (NZTA) *The official New Zealand Truck Loading Code.*

> NZTA *Heavy Vehicle Stability Guide.*

> NZTA *Ministry of Transport Signs and Markings Manual (MOTSAM).*

> NZTA *Traffic Control Devices Manual (TCDM).*

> NZTA *Code of Practice for Temporary Traffic Management (COPTTM).*

## WORKSAFE PUBLICATIONS

> *Approved Code of Practice for Excavations for Shafts and Foundations.*

> *Approved Code of Practice for Load-lifting Rigging.*

> *Approved Code of Practice for Managing Hazards to Prevent Major Industrial Accidents.*

> *Approved Code of Practice for Operator Protective Structures on Self-Propelled Mobile Mechanical Plant.*

> *Approved Code of Practice for the Management of Noise in the Workplace.*

> *Approved Code of Practice for Training Operators and Instructors of Powered Industrial Lift Trucks (Forklifts).*

> *Best Practice Guidelines for the Safe use of Machinery.*

> *Best Practice Guidelines for Working at Height.*

> *Ergonomics of Machine Guarding Guide.*

> *Fact Sheet: A Hazard Management System for Mining Operations.*

> *First Aid for Workplace, A Good Practice Guide.*

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> *Guide to Developing Safety Management Systems for the Extractives Industry.*

> *Guide to Health and Safety in Welding.*

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> *Health and Safety in Contracting Situations.*

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> *Safe Working in a Confined Space.*

> *Safety Code for Forklift Truck Operators: Front Loading Forklift Trucks.*

> *Welding Health and Safety Assessment Tool.*

> *Workplace Exposure Standards.*

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- Coalpro and Quarries National Joint Advisory Committee (QNJAC) – *Traffic Management in Quarries.*
- Health and Safety Executive (HSE) *Approved Code of Practice (ACOP) and Guidance for Health and Safety at Quarries.*
- HSE *ACOP and Guidance – Safe use of Work Equipment.*
- HSE *HSG136 – An Employer's Guide to Workplace Transport Safety.*
- HSE *HSG144 – The Safe use of Vehicles on Construction Sites.*
- HSE *Safe Maintenance Guidance: Falls of Heavy Items, Isolations and Permit to Work, and Hazards during Maintenance.*
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- HSENI *Guidance Document: Geotechnical Appraisal and Assessment.*
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- IRSST *RG-597 Prevention of Mechanical Hazards (chapter 6).*
- US Department of Labour Mine Safety and Health Administration (MSHA) *Number PH01-I-6: Dump-point Inspection Handbook.*
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- MSHA *Controlling Mercury Hazard in Gold mining: A Best Practices Toolbox.*
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- NSW Trade and Investment *MDG 1010:2011 Minerals Industry Safety and Health Risk Management Guideline.*
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- QNJAC *Toolbox Talk: Inspections of Rock Faces.*
- Queensland Government Department of Employment, Economic Development and Innovation *Safety Alert No. 44 V2 Prevention and Management of Blast Fumes (March 2011).*
- Queensland Department of Mines and Energy H&S Division *Safety Bulletin (SB 6): Handling & Management of Surface Trailing Cables.*
- Queensland Department of Mines and Energy *Guidance Note QGN10 Handling Explosives in Surface Mines and Quarries.*
- Queensland Government Mines Inspectorate *Safety Bulletin No. 101: Brake System Maintenance – Rubber Tyred Vehicles.*
- Safe Work Australia (SWA) *Draft Code of Practice: Ground Control in Open Pit Mines.*
- US Department of Labour Occupational S&H Administration (OSHA) *Safety and Health Information Bulletin SHIB 01-25-2013: Hazards of Operating Unguarded Stone Cutters and Splitters in Landscaping and Other Worksites.*
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- Western Australia Department of Mines and Petroleum (DMP) *Guideline Open Pit Mining through Underground Workings.*
- DMP *Safety Bulletin No 65: Design and Operation of Dredges on Ponds.*
- DMP *Tyre Safety, Fires and Explosions – Guideline.*
- WorkSafe Victoria *Guidance Note: Preventing Falls from Quarry Faces.*
- WorkSafe *Victoria Safety Alert: Preventing Mobile Plant Fires.*


**WEBSITE LINKS**


- WorkSafe's emergency procedure flipchart www.business.govt.nz/worksafe
- Information on drivers medical nzta.govt.nz/resources/results.html?catid=53
- Information on HSNO requirements www.business.govt.nz/worksafe
- Information on inspecting small dams, constructing small dams or the Building Code www.dbh.govt.nz/small-dams-guidance
- Information on maritime law and associated requirements www.maritime.govt.nz
- Information on ratio/grade conversions www.1728.com
- Information on transport law and road signs and markings www.nzta.govt.nz
- NIOSH Final Report: Blind Area Study – Large Mining Equipment – Blind area diagrams for selected mining vehicles.


**STANDARDS**


- AS 2187.2-2006 Explosives – Storage and Use Part 2: Use of explosives.
- AS 2359.13-2005 Powered industrial trucks – Brake performance and component strength.
- AS 2359.2-2013 Powered industrial trucks – Operations.
- AS 2865-2009 Confined Spaces.
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> AS/NZS 3007:2013 Electrical equipment in mines and quarries – Surface installations and associated processing plant.
> AS/NZS 3760:2010 In-service safety inspection and testing of electrical equipment.
> AS/NZS 4602.1:2011 High visibility safety garments – Part 1: Garments for high risk applications.
> AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines.
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> NZS 5823:1989 Specification for buoyancy aids and marine safety harnesses and lines.
> NZS 5823:2001 Specification for buoyancy aids and marine safety harnesses and lines.
> NZS 5823:2005 Specification for buoyancy aids and marine safety harnesses and lines.
> SA/SNZ HB 436:2013 Risk management guidelines – Companion to AS/NZS ISO 31000:2009.
> SA/SNZ HB 89:2013 Risk Management – Guidelines on risk assessment techniques.

**LEGISLATION**

> *The Building Act 2004.*
> *Building (Dam Safety) Regulations 2008.*
> *The Building Regulations 1992 (Building Code).*
> *Electricity Act 1992.*
> *Electricity (Safety) Regulations 2010.*
> *Employment Relations Act 2000.*
> *Hazardous Substances and New Organisms Act 1996 (HSNO).*
> *Hazardous Substances (Classes 1 to 5 Controls) Regulations 2001.*
> *Hazardous Substances (Disposal) Regulations 2001.*
> *Hazardous Substances (Identification) Regulations 2001.*
> *Hazardous Substances (Packaging) Regulations 2001.*
> *Hazardous Substances (Tracking) Regulations 2001.*
> *Hazardous Substances (Fireworks, Safety, Ammunition, and Other Explosives Transfer) Regulations 2003.*
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## APPENDICES

IN THIS SECTION:


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23.2 Appendix B: Issuing permit to work certificates

23.3 Appendix C: Field data collection

23.4 Appendix D: Geological models

23.5 Appendix E: Types of analysis

23.6 Appendix F: Batters and final bench design

23.7 Appendix G: Rock bolting systems

23.8 Appendix H: Retaining type structures

23.9 Appendix I: Culverts

23.10 Appendix J: Traction

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23.12 Appendix L: Monitoring methods

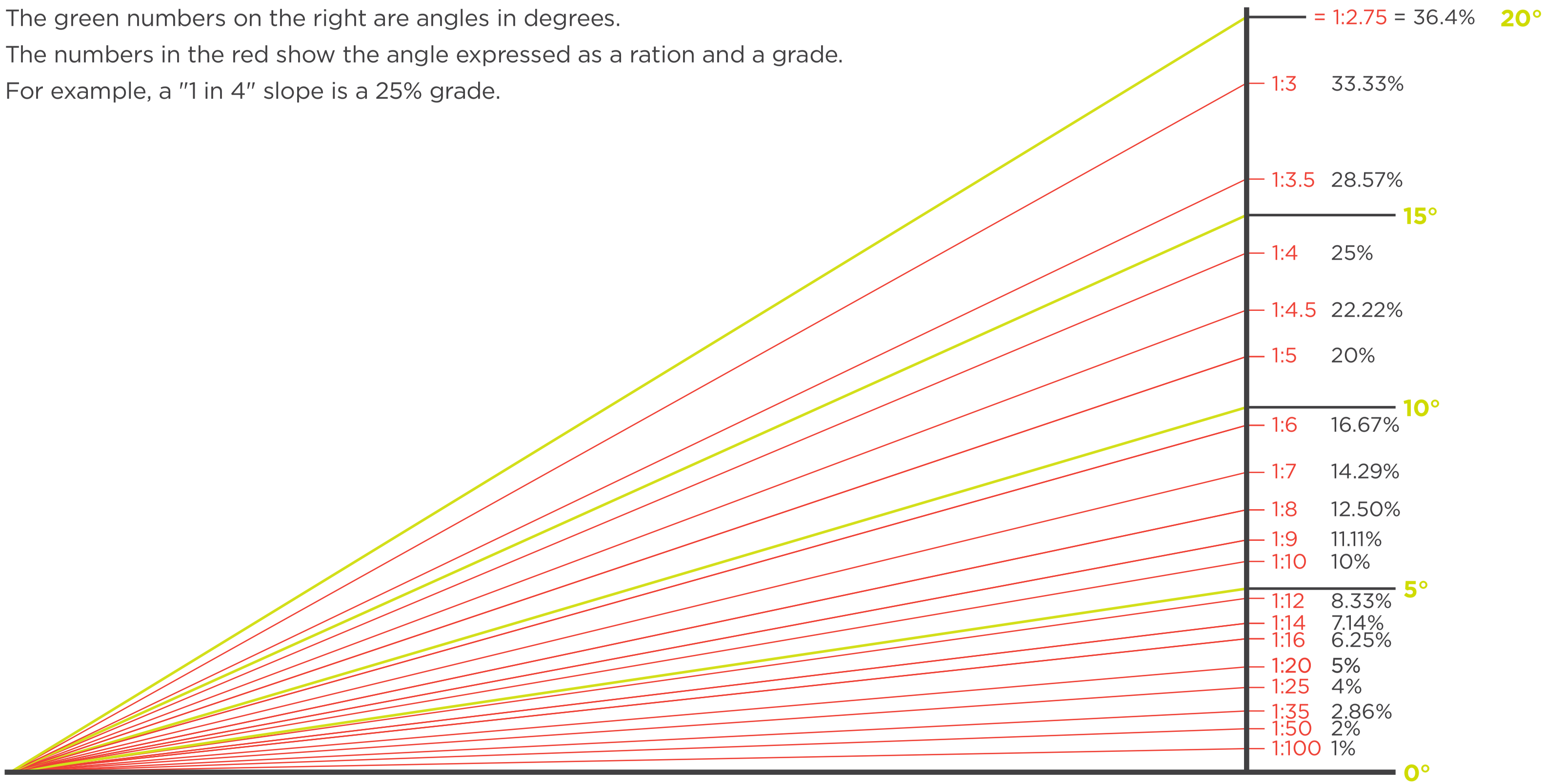
23.13 Appendix M: Instrument data

23.14 Appendix N: Isolation and lockout of energy

23.15 Appendix O: Permit to work system process

## 23.1 APPENDIX A: RATIO TO PERCENTAGE GRADE CONVERSION

The green numbers on the right are angles in degrees.
The numbers in the red show the angle expressed as a ration and a grade.
For example, a "1 in 4" slope is a 25% grade.




Source: www.1728.com

## 23.2 APPENDIX B: ISSUING PERMIT TO WORK CERTIFICATES

| WORK TO BE DONE | POSSIBLE HAZARDS | TYPE OF PERMIT (OR CERTIFICATE) | SOME PRECAUTIONS TO CONSIDER | SOME EQUIPMENT TO CONSIDER |
|---|---|---|---|---|
| **Entry into a vessel, sump, pit or other confined space** | > Oxygen deficiency<br>> Oxygen enrichment<br>> Toxic or corrosive gases<br>> Flammable gases or liquids<br>> High temperature<br>> Low or cryogenic temperature<br>> Toxic or flammable residues | Confined Space Entry | > Atmosphere analysis<br>> Material removal or steaming out<br>> Forced ventilation<br>> Fresh air supply<br>> Physical isolation<br>> Temperature normalisation<br>> Rescue equipment<br>> Standby people | > Toxic or flammable gas and oxygen monitor<br>> Safety harness and hoist<br>> Breathing apparatus<br>> Resuscitator<br>> Respiratory protective equipment (RPE) |
| **Working on or breaking into pipelines or pressure vessels** | > Toxic or corrosive gases or liquids<br>> Flammable gases or liquids<br>> Cryogenic liquids<br>> High pressure<br>> Vacuum | Pipework and Vessels | > Physical isolation<br>> Material removal or steaming out<br>> Inert gas plugging<br>> De-pressurising<br>> Atmosphere analysis<br>> Spill containment | > Helmet<br>> Visor or safety glasses<br>> Ear protection<br>> Gloves<br>> RPE<br>> Toxic or flammable gas monitor<br>> Spill clean-up kit<br>> Fire extinguishers |
| > **Welding**<br>> **Brazing**<br>> **Soldering**<br>> **Grinding**<br>> **Flame cutting** | > Flammable gases or liquids<br>> Combustible liquids or solids<br>> Explosive dusts<br>> Flammable residues<br>> Rubber lined vessels | Hot Work | > Remove materials or cover with fire blanket<br>> Atmosphere analysis<br>> Material removal or steaming out<br>> Inert gas purging<br>> Post work checks | > Fire extinguishers<br>> Hose reel<br>> Fire blanket<br>> Toxic or flammable gas and oxygen monitor<br>> Sand<br>> Sand bucket |

| WORK TO BE DONE | POSSIBLE HAZARDS | TYPE OF PERMIT (OR CERTIFICATE) | SOME PRECAUTIONS TO CONSIDER | SOME EQUIPMENT TO CONSIDER |
|---|---|---|---|---|
| **Work at height (injury from falling possible)** | > Fragile roof<br>> Overhead lines<br>> Electricity<br>> Chimney or exhaust stack emissions<br>> Soft ground<br>> Vehicle movement<br>> Weather conditions | Work at Heights | > Isolate and lock off power to overhead electrics<br>> Provide safe access and place of work<br>> Atmosphere analysis<br>> Stop emissions<br>> Clear and cordon off ground beneath work area | > Scaffolding<br>> Crawl boards<br>> Edge protection<br>> Safety harness and fixing<br>> Toxic or flammable gas and oxygen monitor<br>> RPE<br>> Elevated work platform |
| **Repair or maintenance of powered machinery** | > Electricity<br>> Gas<br>> Moving parts<br>> Stored energy eg eccentric shafts | Electrical and Machinery Isolation | > Electrical isolation<br>> Switches locked off<br>> Warning notices (tags)<br>> Stored energy dissipated | > Circuit tester<br>> Personal padlocks<br>> Specialist lockout devices<br>> Warning notices (tags) |
| **Digging or excavating (other than extraction of product)** | > Underground services<br>> Electric cables<br>> Gas pipes<br>> Water mains<br>> Solvent or corrosive pipes<br>> Compressed air<br>> Drains or sewers<br>> Overhead cables | Digging or Excavation | > Locate and identify underground services<br>> Provide shoring in trenches<br>> Atmosphere analysis | > Underground cable detector<br>> Toxic or flammable gas and oxygen monitor |
| **Examples:**<br>**> Asbestos removal**<br>**> One-off work with hazardous substances**<br>**> Demolition**<br>**> Installation projects**<br>**> Construction work**<br>**> Disconnecting or isolating emergency systems (eg alarms, automatic extinguisher systems)** | To be identified | Special | To be identified<br>Specialist advice may be needed | To be identified |

## 23.3 APPENDIX C: FIELD DATA COLLECTION

There are several tools and techniques available for field data collection. These include:

> **Surface geophysical** data collection methods provide initial identification of major lithological units and structural features, such as fracture zones.

> **Downhole geophysics or logging** provides data that can be used to determine lithological boundaries, structures and the in situ mechanical, physical and chemical properties of the rock mass.

> **Core drilling** enables an adequate understanding of the subsurface conditions for input to geotechnical design. The number of boreholes required will depend on:

- the level and reliability of already available geological and geotechnical information
- the complexity of site geology
- the size and operating life of the quarry or mine.

Core samples retrieved from boreholes can be logged using direct observation, or downhole cameras and digital photography.

> **Field testing**: Geotechnical data collection from exposed rock can be carried out using 3D digital photogrammetric techniques.

> **Laboratory testing**: Rock samples can be tested in a laboratory to determine intact rock properties.

## 23.4 APPENDIX D: GEOLOGICAL MODELS

### 23.4.1 THE GEOLOGICAL MODEL

The purpose of the geological model is to show a three dimensional (3D) visualisation of the materials present. Different material types often have different strength characteristics, which affect the process of slope design.

Use a competent person to develop an accurate, well-understood geological model. This requires an understanding of geological events that led to the formation of the ore body, regional and local structure, lithology, topography, morphology and regional stress field as well as geotechnical requirements for slope design.

#### THE STRUCTURAL MODEL

The purpose of the structural model is to describe the orientation and spatial distribution of the structural defects (discontinuities) that are likely to affect the stability of slopes. The defects can be divided into two groups:

> large structural features such as folds and faults that are widely spaced and continuous along strike and dip across the entire site (major structures)

> closely spaced joints, cleavage and faults that typically do not extend for more than two or three benches or batters (minor structures).

Use a competent person to develop structural models.

The structural model can be developed using computer based 3D modelling tools. Ideally, the major and minor structures are recorded in at least two separate overlays. This allows efficient assessment of their combined effect as well as individual effects on the stability of the slope.

#### ROCK MASS MODEL

A rock mass model shows the engineering properties of the rock mass made up of various material types and structural defects. The rock mass properties include the intact pieces of rock, the structures that cut through the rock and the rock mass itself. These properties govern the performance of the slope and therefore the design approach.

In a slope constructed in stronger rock, failure can occur along geologic structures which are considered pre-existing planes of weakness in otherwise solid rock. In relatively weak materials (ie weathered or soft rock) failure can occur through the intact material or along geologic structures. In some situations (in strong rocks as well as in weak materials) failure could occur partly along geological structures and partly through intact rock material. It is therefore important to determine the engineering properties of:

> intact rock or soil
> structural features
> the rock mass in the various geological units.

HYDROGEOLOGICAL MODEL

The presence of groundwater in a slope can have significant negative effects on stability. In the case of sites excavated within weak materials (eg clay or completely weathered rock) pore pressures play a significant role in stability. High pore pressures reduce the effective stresses and simultaneously reduce the shear strength of both soil or rock material and rock mass. High water pressures also reduce the shear strength of structural defects in un-weathered strong rock. This leads to structurally controlled instability.

Groundwater (depending on chemistry) can contribute to corrosion of ground support and reinforcement, if used as a method of slope stabilisation. This would significantly reduce their effectiveness.

Groundwater can also create saturated conditions and lead to water ponding within an excavation which can lead to unsafe conditions. Other problems that could result from saturated conditions or standing water include loss of access to all or part of the excavation, difficulties in using explosives and reduced efficiency in the equipment used at the site.

It is therefore important to develop a good hydrogeological model early on. This allows effective control measures to be designed and implemented. Preliminary data required for the development of the hydrogeological model can be obtained from boreholes drilled for resource evaluation and geotechnical site investigations. However, purpose designed drilling and testing programs are required for the hydrogeological characterisation of the rock mass.

Use a competent person to carry out hydrogeological modelling.

For more information on groundwater and surface water control see section 3.5.5.

## 23.5 APPENDIX E: TYPES OF ANALYSIS

Basic types of analysis are:

**Rock Mass Rating (RMR) and Mining Rock Mass Rating (MRMR) Classification Systems**: At early stages of site development, if data is limited and the geotechnical model has not been fully developed. Here empirical approaches based on rock mass classification methods such as RMR and MRMR can be used for preliminary slope design. These methods are largely based on qualitative studies of rock mass failures and are only considered useful for initial assessment of failure through the rock mass (Jakkubec J. and Esterhuizen).

**Kinematic analysis of structurally controlled failures**: The analysis of removability of rock blocks from the slope without referring to the forces that cause them to move. It is based on stereographic projections and is mainly applied to batter designs. It may also be used for large scale slope design, if anticipated failure is controlled by structures.

**Limit equilibrium analysis**: A two-dimensional method of analysis widely used for the determining Factor of Safety against rotational shear failure in soil slopes. It can be applied to assess structurally controlled "kinematically unstable" rock block and wedges in batter and inter-ramp scale. It can also be used to assess against failure through rock material or rock mass in batter, inter-ramp and overall slopes. The major limitations of limit equilibrium analysis are that it assumes the unstable mass can be characterised by solid blocks and it cannot represent either deformation or displacement of the failing rock mass.

**Numerical analysis**: Numerical analysis is based on numerical modelling tools such as finite element and distinct element methods. It can overcome some of the limitations of limit equilibrium analysis as it can model complex rock masses and the deformation and displacement of the failing mass. This analysis is useful for the assessment of both inter-ramp and overall slopes in large opencast mines or quarries.

## 23.6 APPENDIX F: BATTERS AND FINAL BENCH DESIGN

### BATTER HEIGHT AND REACH

The maximum height of a batter should be based on stability and should not exceed the safe reach of the equipment available to clean (scale) the face, unless special precautions are taken. These precautions could include:

> blasting practices that shoot the face clean
> using mobile plant or equipment capable of working a safe distance from the toe while removing material to the toe
> using mobile plant or equipment to clean the face from the top edge
> excavating the batter face in lifts from top to bottom to allow to allow for cleaning immediately above the work area
> providing a buffer (ie a windrow or ditch) of sufficient size to capture any potentially hazardous rock falls.

The height of batters should be determined on an individual basis, based on past extraction conditions of the seam or area, and sound engineering practices.

### FINAL BENCH SPACING

Benches perform two important functions. First, they provide stability to a slope by increasing the safety factor. Where a slope contains numerous discontinuities (joint sets, bedding planes, and so on) providing benches at select spacings can increase the stability of the slope. Second, where rilling rock and dirt are a problem, benches can be used to keep these materials from falling into working areas. As such, whether the bench can do these is one of the factors used to determine bench spacing.

Where bench spacing has been decreased to a minimum and rill material is still not contained (smaller size material) you must determine if a significant hazard is present. Material only falling at the base of the batter may not be a hazard, as it does not affect a travel or work area. However, work near the batter should be considered when considering if there is a hazard.

If the configuration of the batter or techniques being used do not keep material from falling into the excavation where workers are exposed, changes to the ground control methods will be necessary. Providing a bench or additional benches in the slope, widening bench widths, modifying blasting techniques, changing the orientation of mining or extraction, and more effective cleaning methods are some of the changes to consider.

### FINAL BENCH WIDTHS

The width of benches should be determined by three factors:

> The bench should be wide enough to stop potentially hazardous rock falls and contain any material that falls from the wall above the bench. This is unless other controls are in place (ie rock fences).

> Extended exposure of the wall can cause rilling material to accumulate on the bench. Cleaning may be needed to maintain the bench's effectiveness. If you are cleaning benches the bench width should accommodate any equipment used on the bench. Safe access to the bench must be provided.

> Bench widths should allow for adequate drainage, as described in section 3.5.5.

When designing bench widths the likelihood of achieving the design width should be considered. Even with good blasting and excavation control, the design may not be achieved. The width that can practically be achieved depends on the amount of back-break occurring along the crest during excavation. Back-break from blasting can extend into the bench as much as 3 metres. Presplitting can reduce back-break if the holes are spaced close enough, and plugged as near the top of the hole as possible. This reduces the amount of stemming. Explosive contractors or suppliers may offer other techniques that could be used to handle back-break problems.

## 23.7 APPENDIX G: ROCK BOLTING SYSTEMS

**Rock bolts** are tensioned once anchorage is achieved, to actively set up a compressive force into the surrounding rock. This axial force increases the shear capacity and is generated by pre-tensioning of the bolt. In essence, rock bolts start to support the rock as soon as they are tensioned.

Commercially available rock bolts include cone and shell, grouted and chemically (resin) anchored rebar.

**Rock dowels** can be used instead of rock bolts, when installation of support can be carried out very close to the excavated face or in anticipation of stress changes that will occur at a later excavation stage. Rock dowels are passive reinforcing which need some ground displacement for activation.

**Cable bolting** is an established technique used extensively for reinforcement of the rock mass adjacent to surface excavations. They can be tensioned or un-tensioned, and may be fully or partially grouted. Thread-bar rock anchors or multi-strand tendon cable anchors can be used where higher loads are required.

**Shear pins** are reinforcement bars or larger steel, concrete or post sections that may be grouted in situ. They are designed to be placed perpendicular to a particular discontinuity and to act mainly in shear. The support provided by the shear pin is equal to the shear strength of the steel bar and possibly the cohesion of the rock/concrete surface.

Although shear pins are mainly installed perpendicular to the potential slide plane, there are some other applications. These can involve horizontal installations to provide shear support to blocks defined by flat-lying underground workings intersecting the pit wall, or unstable clay seams within an eroded rock wall.

**Mesh**, where bolting alone is insufficient and support is required for small fractured material, welded or arc mesh secured to the rock bolts, dowels or cable bolts is a suitable form of support. Usually a 100 x 100 mm mesh is used, but the size is determined by the desired bag strength. The use of mesh in very blocky ground reduces the potential for unravelling and can be a very useful ground support method.

**W strapping** is used to connect the collars of rock bolts. They are nominally 2-3 mm thick and 200-300 mm wide, and can be bolted to follow the contours of the rock face. Support tension can be exerted between bolt sets through the strap.

## 23.8 APPENDIX H: RETAINING TYPE STRUCTURES

**Gabion walls** are a traditional effective and practical means of stabilising cuts and slopes. As they apply a surcharge load to the underlying pit wall, they must be installed upwards from a location where there is strong enough rock for a suitable foundation.

**Stacked tyres** are an alternative to gabions, and may be simpler and cheaper to install. Each stack of tyres should be filled and secured.

**Reinforced earth** retaining walls are gravity structures consisting of alternating layers of granular backfill and reinforcing strips with a modular precast concrete facing. Because of their high load-carrying capacity, reinforced earth is ideal for very high or heavy-loaded retaining walls.

**Tied-back walls** generally comprise a concrete wall, often reinforced with mesh or reinforcement bars tied back into the rock wall using cable bolts, or rock bolts in smaller structures. These walls are particularly suited to mining applications where they can be constructed progressively as the benches are mined, using cable bolting meshing and a shotcrete application.

**Steel sheet piling** is often used in soft soils and tight spaces. They are made out of steel, vinyl, fibreglass or plastic sheet piles driven into the ground and can require a tie-back anchor ‘dead man’ tied by a cable or a rod. For more detailed information on shoring methods see the WorkSafe *Approved Code of Practice for Excavations and Shafts for Foundations.*

## 23.9 APPENDIX I: CULVERTS

Unless the culverts lead to additional diversionary ditching, provide water run-outs to reduce the velocity to where the water is non-erosive. On shallow slopes (less than 10%) with limited water flows (<0.5 m/s), this can be done with vegetated outflow areas. Energy dissipaters (riprap or tipped rock) may be required where flow rates are higher.

Provide and maintain good drainage to ensure low water levels in the road fill in areas of a naturally occurring high water table (eg swamps or watercourses).

Temporary in-pit roads with high ground water levels can be improved by placing gravel or rockfill over the area, or by installing pumping wells to lower the water table. Pumping wells may be cost effective if it also reduces the water level in, and improves the stability of, the working area.

Make drainage features large enough, and space them apart so they can deal with the greatest expected demands on them.

While it is raining or right after it rains, is a good time to check drainage is working properly.

## 23.10 APPENDIX J: TRACTION

The forces required for accelerating, turning, or stopping vehicles are caused by the friction generated between the tyres and the road pavement. The amount of friction available varies with different road pavements and is indicated by a friction coefficient, which is a measure of how well the tyre grips the road pavement.

The friction coefficient indicates how much of the total weight of the vehicle can be generated as a force between the tyre and the road pavement. The higher this force, the better the grip on the road and the more control the driver has in climbing, steering, and stopping.

Table 8 shows some typical friction coefficients for a variety of road pavements. Notice the significant differences in values varying from concrete (0.9) down to ice, which can be practically zero. The value of 0.9 for rubber tyres on concrete means 90% of the weight on a tyre is available as braking force (presuming that the brake components themselves can provide this much braking force).

| PAVEMENT MATERIAL | DRY | WET |
|---|---|---|
| Clay | 0.60 – 0.90 | 0.10 – 0.30 |
| Concrete | 0.90 | 0.60 – 0.80 |
| Gravel road, firm | 0.50 – 0.80 | 0.30 – 0.60 |
| Gravel road, loose | 0.20 – 0.40 | 0.30 – 0.50 |
| Ice | 0.00 | 0.00 |
| Sand, loose | 0.10 – 0.20 | 0.10 – 0.40 |
| Snow, packed | 0.10 – 0.40 | 0.00 |

**Table 10:** Typical values for the coefficient of friction between rubber tyres and various road surfaces

These different values show why it is so important drivers adjust their speed to suit the road conditions. All other factors being equal, it will take a longer distance to stop when the traction values are low. If the friction coefficient is reduced by half the stopping distance is doubled once the brakes are applied. Friction values also affect steering ability. Reduce speed when traction is low.

The road pavement coefficients given in Table 10 are the maximum values for the conditions indicated. Maximum tyre grip occurs when the tyre is still rolling and just before the tyre would lockup and slide. Once a tyre locks up and goes into a skid, the available friction is reduced. This reduction can be as much as 50% under poor road conditions. This is why antilock brakes are of such benefit. They help prevent tyres from locking up, so the available friction stays at the higher values. Brakes stop the wheel, but it's the grip between tyre and road pavement that stops the vehicle.

## 23.11 APPENDIX K: WINDROWS

One way for a windrow to provide restraint is for the windrow to deflect the tyre, and re-direct the vehicle back onto the road. To do this, make the windrow material firm, and the inside slope as nearly vertical as possible (a slope of greater than 40° is recommended[92]). When cutting the inside slope to steepen the windrow, make sure enough material is initially placed so once the windrow is cut, the base width is still adequate. Make the base width at least the width the windrow would have been if both its outside and inside slopes were at the material's angle of repose. Maintain a full base width to serve the function of keeping vehicles back from the edge (refer 5.3.9).

Windrows constructed of broken rock mixed with bonding materials will normally offer restraint due to the interlocking and frictional resistance of the rock pieces. If a windrow is too loose, it will provide little restraint and the vehicle may plough straight through it. If a windrow is firm, but is not steep on the roadway side, the vehicle could ride up and over it (refer 5.3.9).

A windrow can also impede the passage of a vehicle by a combination of the tyre sinking into and raising up as it climbs the windrow material. The vehicle may get bogged down as it plows through. But to effectively impede a vehicle in this way, a windrow generally needs to be larger than axle height. In general the finer the material used, and the less effort that is made in compacting and shaping a windrow, the larger the windrow should be to provide similar restraint.

[92] Source: Source: Stecklein, G. L. (1981) *Haul road berm and guardrail design study and demonstration* (US Bureau of Mines), Restraint system recommendation, p160

Because of the large size and weight of some vehicles, the typical axle-height berms cannot be relied on, by themselves, to completely stop a vehicle except at low speeds. Windrows much larger than axle-height are required to completely stop a vehicle for all possible conditions of speed and impact. Tests have shown a windrow needs to be constructed to a height 3 times the axle height for vehicles under 85 tonnes and 4 times the axle height for vehicles over 85 tonnes to stop a runaway vehicle. This is based on a vehicle contacting the windrow at 48 kilometres at a 30 degree angle of contact[93].

The amount of restraint offered by a windrow depends on the conditions under which the vehicle impacts it. The greater the vehicle speed, or the more head-on the vehicle contacts the windrow; the larger the windrow has to be. For this reason, use larger than typical windrows in areas where it is reasonable to expect more adverse conditions, such as where vehicles would have more speed or would contact the windrow head-on. An example would be where there is a curve at the bottom of a grade. In such cases, increase windrow size or consider other provisions, such as runaway lanes or double windrows (refer 5.3.10).

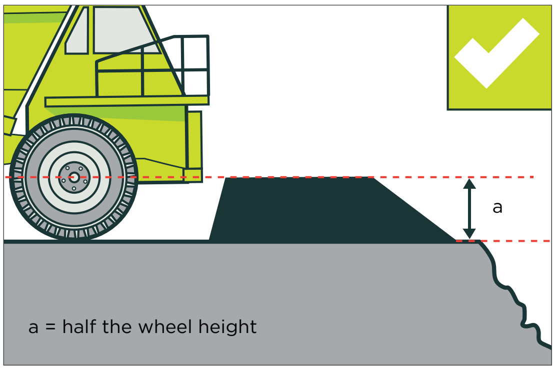



**Figure 104:** Suitable windrow – firm material big enough to absorb the vehicle's momentum with a steepened inside slope

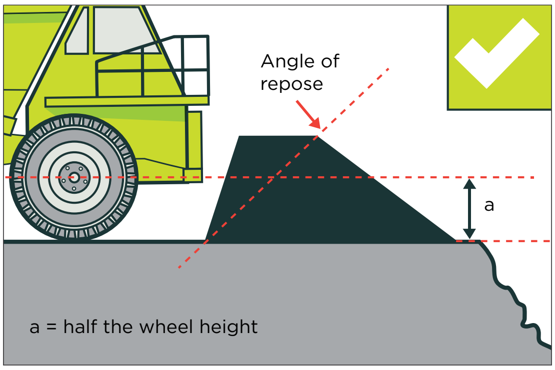



**Figure 105:** Suitable windrow – the width of the windrow is as wide as the normal angle of repose

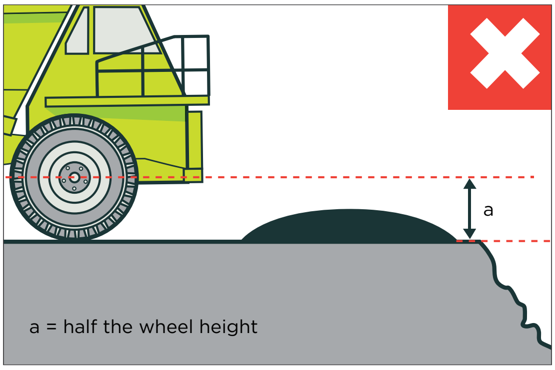



**Figure 106:** Unsuitable windrow – curved slopes

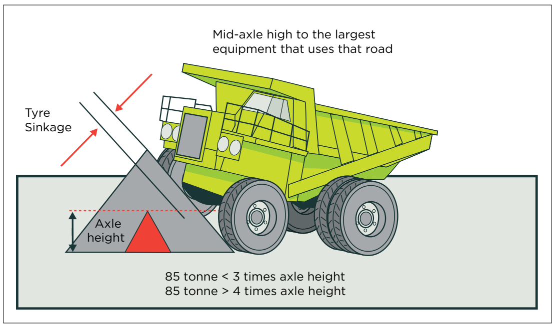



**Figure 107:** Study on windrow size to offer definite restraint

Make roads wide enough so windrows are constructed on a firm foundation that is level with the roadway. If the road width is inadequate and a portion of the windrow extends over the hillside, the windrow will be more likely to give way when hit and offer little restraint (refer Figure 108).

[93] Source: Stecklein, G. L. (1981) *Haul road berm and guardrail design study and demonstration* (US Bureau of Mines)

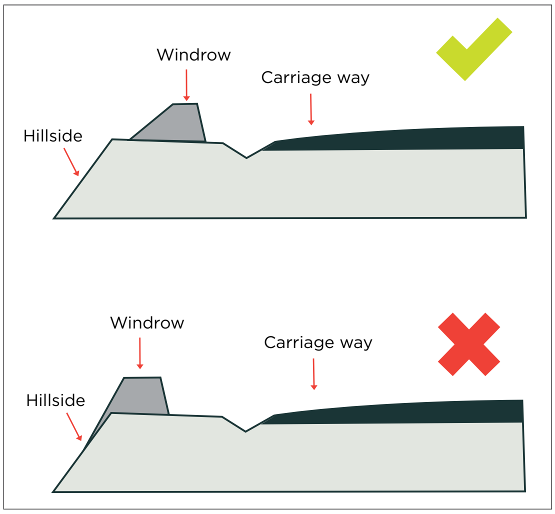



**Figure 108:** Windrow constructed on firm foundation

Leave gaps in the windrow or other drainage systems provided where necessary, to allow drainage of surface water. Make sure any gaps are not wide enough for a vehicle to pass through. Design them so a vehicle's wheel cannot be trapped at an angle leading away from the travelling direction (see Figure 109).

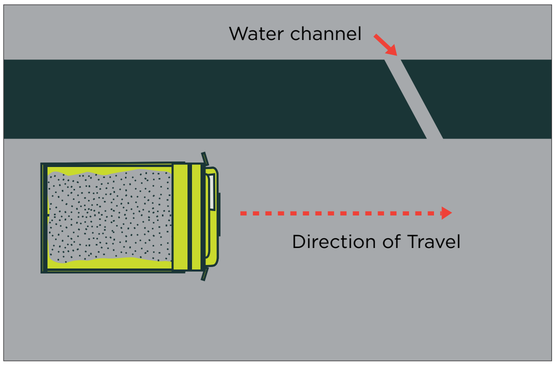



**Figure 109:** Suitable windrow – gaps in windrow for drainage

## 23.12 APPENDIX L: MONITORING METHODS

### VISUAL INSPECTION

A basic element of a slope movement monitoring program should be visual inspection by a competent person, combined with observation by all workers. Maintain this qualitative, but extremely important aspect of the program throughout the life of the operation.

Workers are required to report rock falls, and be involved in the slope inspection process and in a regular detailed inspection process.

Any visual monitoring program should be supported by instrumentation to provide a quantitative basis for defining any movement.

Develop and implement a procedure for the regular inspection of faces above every place of work and every road used by workers[94]. This is good practise for all quarry and alluvial mine operators, and a legal requirement for other mine operators as defined in section 19M of the *Health and Safety in Employment (Mining Operations and Quarrying Operations) Regulations 2013.'*

The procedure must ensure:

> A competent person examines every area of the site where a worker is present, or is expected to be present, before every shift and at suitable times during the shift.

> Every accessible area of the site (including areas containing barriers, machinery and infrastructure) is examined at least weekly.

It must also ensure that written procedures are available for workers, setting out:

> What will be examined?

> When they will be examined?

> How inspections will be recorded?

> How findings will be actioned?

[94] The Regulations, regulation 222

Practical information and advice on actions to be taken when defects are identified may include:

> if it is safe to work below and above a face
> if there is any loose material on the face
> if there is potential for instability
> whether maintenance is required to the face prior to commencing work
> when further advice is required such as from the geotechnical specialist.

SURFACE EXTENSOMETERS AND CRACK MONITORING

If evidence of movement is detected from visual inspection, the first step in increasing the monitoring program might be simple crack monitoring. Results of visual inspections and crack monitoring are a useful guide when selecting additional secondary monitoring points for detailed survey assessments.

Crack monitoring techniques typically consist of:

> regular detailed mapping of location, depth, width of cracks, rate of extension and opening
> installation of targets on opposite sides of cracks to monitor rates of opening
> installation of surface (wireline) extensometers
> installation of picket lines or line of targets that can be monitored using theodolites or precise levels to detect changes in alignment, location of elevation along a given crack or the crest of the slope.

Surface extensometers for monitoring local wall movement or tip movement can be easily constructed and provide a rugged practical system of monitoring that can be inspected and interpreted regularly by operational workers. They can also be equipped with automatic devices such as lights or sirens to provide warning of excessive movement. More sophisticated units can provide real-time indication of movement to remote locations (ie offices) through a telemetric link.

TERRESTRIAL GEODETIC SURVEYS

The most reliable and complete measurements associated with initial movement can be obtained from conventional geodetic survey techniques, using precise theodolite and electro-optic distance measuring (EDM) combinations or total stations. These systems can be installed by survey workers, generally with survey equipment in regular use at a site.

Primary monitoring points should be surveyed at regular intervals, consistent with the type of rock and expected rates of movement. Surveillance monitoring frequencies vary from weekly to quarterly depending on conditions such as the stage of mining or extraction, mining or extraction rate, changes in piezometric surface and climatic variations.

The individual aspects of a typical system are:

> Control points for the system should consist of the instrument stations near the crest of a slope and reference stations located away (100 metres to 3 kilometres) from mining or quarrying activities. Control points are usually established by conducting a first-order survey, using conventional survey techniques such as triangulation, trilateration or triangulateration, or GPS.
> GPS is much more efficient, accurate and less labour-intensive than the conventional survey techniques when used for control surveys, especially when the network covers a relatively large area. The main requirements are that the system used picks up variances and good quality equipment.
> The stability of instrument stations can be checked by resurveying the control network or reference stations each time the instrument station is used. Make sure reference stations are observed regularly.

Plot and assess data from the survey after each set of readings. If movement is detected, monitoring frequency of secondary points will depend on the size of the failure and movement rates and could be hourly to weekly. For more detailed information on data analysis see section 7.4.

For more detailed information on surveying see the *Approved Code of Practice for Surveying*.

GPS STATIONS

Global positioning systems (GPS) based on satellites orbiting the earth can be used for real-time positioning at any location 24 hours a day in any weather. The positioning is accomplished through the use of timing signals transmitted by the satellites to ground receivers.

With two or more receivers working simultaneously in a so-called differential mode, you can measure relative positions (3D coordinate differences) between the receivers. This will have an accuracy of a few millimetres to about 20 mm over distances up to several kilometres.

Unlike conventional survey techniques (ie those using EDM, total stations and levels) GPS does not require a direct line of sight between survey stations. GPS is not affected by local atmospheric conditions when the GPS baseline length is within 1 km, so GPS is usually more efficient and accurate, and requires less labour than conventional survey techniques. Therefore, GPS has been adopted as the general surveying technique at many extractive sites. The advantages also make it an ideal tool for setting up control surveys for slope monitoring.

RADAR

Where more extensive areas of movement are detected, radar enables real-time monitoring of the movements to help ensure workers below the slope are kept safe. Radar units used in conjunction with geodetic surveying can effectively provide real-time warning of movements and accelerations.

It is important that radar is not the sole basis for monitoring. Further, it is essential to maintain a degree of conservatism in determining when to withdraw workers from below a moving slope, even if it is being monitored by radar. Even small rock falls resulting from the deformation can have serious safety consequences and may not be detected by radar.

SUBSURFACE TECHNIQUES

Costs of subsurface techniques are greater than those for surface instrumentation. These costs can be modest, if available drilling equipment is used and workers perform the installation after instruction from specialists or the instrument supplier. Inclinometers and TDR cables, for example, give very valuable and precise information on the locations of deep-seated slide surfaces, and on rates of movement without which remedial work cannot be adequately planned.

MICRO-SEISMIC MONITORING

Routine real-time micro-seismic monitoring in the opencast environment can provide 3D data where rock breakage or movement is occurring. This data can be used to enhance surface monitoring systems in identifying potential instability and the associated failure mode. The technique is commonly used in underground mining operations and has recently been applied in opencast environments.

MONITORING OF GROUNDWATER PRESSURE

If the slope design is based on achieving a given future pore pressure profile, it is important year-by-year pore pressure targets are developed to ensure depressurisation is occurring at the desired rate.

Include piezometer installations in the most critical areas for slope performance in the final slope design. Target pressures are then developed for each piezometer, for each year of operation.

The components of a groundwater monitoring system could include:

> data acquisition systems
> piezometers
> horizontal drain flows
> dewatering well discharges
> monitoring of slope conditions.

## 23.13 APPENDIX M: INSTRUMENT DATA

### PROCESSING AND PRESENTATION OF INSTRUMENTATION DATA

The primary aim of data processing and presentation is a rapid assessment of information to detect changes that require immediate action. A secondary function is to summarise and present the data to show trends and compare observed with predicted behaviour, so that any necessary action can be initiated.

Present monitoring data in a format that is easy to read and identifies problem areas quickly.

Determine responsibility for processing and presentation of instrumentation data during the planning phase. This should be under the direct control of a competent person on site, or in special cases, consultants who have immediate 24-hour access to the data. Time required for these tasks can be underestimated, resulting in the accumulation of unprocessed data and failure to take appropriate action. Similarly, experienced geotechnical engineers may use much of their time supporting monitoring systems instead of delegating these responsibilities to technicians. This may mean they neglect the required technical analysis to minimise or manage the impacts of potential slope failures. The time required for data processing and presentation is usually similar to, and may even exceed, the time required to collect data.

Data processing and presentation depends on the specific monitoring system. For surveillance monitoring and for small slopes it can often be performed with standard spreadsheet packages. More comprehensive monitoring programs may require commercial survey reduction and geographic information system (GIS) programs.

### INTERPRETATION OF INSTRUMENTATION DATA

Monitoring programs have failed because the data generated was never used. If there is a clear sense of purpose for a monitoring program, this will guide the data interpretation.

Aim early data interpretation at determining the accuracy of the monitoring system. For example, atmospheric changes may result in diurnal variations of several times the manufacturer's quoted accuracy for EDM and total station units. This is common particularly in climates where there are significant temperature differences between day and night or climates where temperature inversions can develop in a pit overnight. Filter out these survey accuracy variations as part of the interpretation process, either by setting wider bands before alarms are triggered or by putting emphasis on readings taken at the same time of the day.

The purpose of subsequent data interpretation is to correlate the instrument readings with other factors (cause and effect relationships) and to study the deviation of the readings from the predicted behaviour. By its very nature, interpretation of data is a labour-intensive activity and no technique has yet been developed for complete automatic interpretation.

#### RESPONDING TO DATA VARIATIONS

Interpretation of data from movement monitoring systems primarily involves assessing the onset of changes in the movement rate. This is generally reflected by acceleration but, where a slope is already moving, deceleration may also occur.

If the material does fail, the site should have a pre-planned response to the movement. This can be achieved through the use of trigger points or trigger action responses (TARPS) established for each monitoring method. A typical system of trigger points might be as follows:

> The initial trigger point would be if the movement rate is double the survey accuracy from the last reading. In this case the reading should be repeated as soon as possible. If the reading is proven correct, additional readings should be taken at an increased frequency.

> The second trigger point would be if the movement rate doubles over two consecutive readings. In this case, the area of the moving prisms should be inspected. If the cause of movement cannot be determined, reduce extraction or mining in the area or suspend it and increase the reading frequency. Until the situation has been fully investigated, continued acceleration of movement should require closure of the pit floor below the moving area.

> If an increase in movement greater than four times the survey error is recorded for any reading, when there has been no previous accelerations noted on a prism, clear the area below the movement prism immediately until the point has been resurveyed. If the reading is confirmed, keep the area clear until the situation has been investigated.

The reporting procedure in the event of any TARP should be clearly defined and understood by all. Slope failures very rarely occur without some warning, and all workers need to be able to recognise potential hazards and act accordingly. It is recommended TARPs also include actions to be taken where monitoring systems or instruments are no longer operational (ie breakdowns).

#### REPORTING CONCLUSIONS

After each set of data has been interpreted, report conclusions in the form of an interim monitoring report, and submit this to workers responsible for implementing remedial actions. At the very least, supply management with a monthly summary report of the results from the monitoring program, even if no movement is detected. A final report of the monitoring program is often required, and a technical paper may be prepared.

## 23.14 APPENDIX N: ISOLATION AND LOCKOUT OF ENERGY

In this section, the term energy refers to anything that can provide power to a system to allow it to perform work. The term system refers to machinery, equipment or processes.

### 22.14.1 TYPES OF ENERGY

The term energy includes any electrical, mechanical, pneumatic, chemical, thermal or gravitational energy. Some energy sources are obvious, such as electricity, heat in a furnace, or something that might fall. Others may be hidden hazards, such as air pressure in a system or a tightly wound spring.

**Electrical energy** is the most common form of energy used in workplaces. It can be available live through power lines or it can be stored, for example, in batteries or capacitors. Electricity can harm people in one of three ways:

1. by electric shock
2. by secondary injury (eg burn)
3. by exposure to an electric arc.

**Hydraulic potential energy** is the energy stored within a pressurised liquid. When under pressure, the fluid can be used to move heavy objects, machinery, or equipment. Examples include braking systems in vehicles or hydraulic lifting arms. When hydraulic energy is released in an uncontrolled manner, individuals may be crushed or struck by moving machinery, equipment or other items.

**Pneumatic potential energy** is the energy stored within pressurised air. Like hydraulic energy, when under pressure, air can be used to move heavy objects and power equipment. Examples include spraying devices, power washers, or machinery. When pneumatic energy is released in an uncontrolled manner, individuals may be crushed or struck by moving machinery, equipment of other items (ie hoses).

**Chemical energy** is the energy released when a substance undergoes a chemical reaction. The energy is normally released as heat, but could be released in other forms, such as pressure. A common result of hazardous chemical reaction is fire or explosion.

**Radiation energy** is energy from electromagnetic sources. This energy covers all radiation from visible light, lasers, microwave, infra-red, ultraviolet, and x-rays. Radiation energy can cause injuries ranging from skin and eye damage to cancer.

**Gravitational potential energy** is the energy related to the mass of an object and its distance from the ground. The heavier an object is, and the further it is from the ground, the greater its gravitational potential energy. For example, a 1 kilogram (kg) weight held 2 metres above the ground will have greater gravitational potential energy than a 1 kg weight held 1 metre above the ground.

**Mechanical energy** is the energy contained in an item under tension. For instance, a spring that is compressed or coiled will have stored energy which will be released in the form of movement when the spring expands. The release of mechanical energy may result in an individual being crushed or struck by the object.

Understand that all of these energy types can be considered as either the primary energy source, or as residual or stored energy (energy that can reside or remain in the system). The primary energy source is the supply of power that is used to perform work. Residual or stored energy is energy within the system that is not being used, but when released it can cause work to be done.

For example, when you close a valve on a pneumatic (air) or hydraulic (liquid) powered system, you have isolated the system from its primary energy source. However, there is still residual energy stored in any air or liquid that remains in the system. In this example, removing the residual energy would include bleeding out the liquid, or venting out the air. Until this residual energy is removed from the system, there is a potential hazard.

Control of energy includes isolating the system from its primary power source **and** removing the residual energy.

### 22.14.2 IS LOCKOUT AND ENERGY CONTROL THE SAME THING?

The terms lockout and isolation are sometimes used interchangeably, but they are not the same thing.

Energy isolation is a broad term describing the use of procedures, techniques, designs and methods to protect workers from injury due to the inadvertent release of energy.

Lockout is the placement of a lock or tag on an energy-isolating device in accordance with an established procedure. It indicates the energy-isolating device is not to be operated until removal of the lock or tag. Therefore, lockout is one way in which energy control can be achieved.

### 22.14.3 ENERGY ISOLATION PROCEDURES

In most cases, equipment or systems will have safety devices built in. These safety devices include guards and safeguarding devices to protect workers during normal operations. However, during maintenance or repairs, these devices may have to be removed or by-passed. In these situations, an energy isolation procedure is needed. Energy isolation procedures may be part of a Permit to Work system (refer section 17.3).

Energy isolation procedures are used to maintain worker safety by preventing:

> unintended release of stored energy
> unintended start-up
> unintended motion
> contact with a hazard when guards are removed or safety devices have been by-passed or removed.

Developing and implementing energy isolation procedures involves 5 steps:

**Gather information**: Gather documentation from the manufacturer or designer of the system about:

> Where energy isolating devices are located and procedures for their use.
> Step-by-step procedures for servicing or maintaining the system.
> How to safely address malfunctions, jams, misfeeds or other planned and unplanned interruptions in operations.
> How to install, move, and remove any or all parts of the system safely.

This information will help you to understand how the system was intended to be used, and will provide you with recommendations on how the tasks can be performed safely.

**Perform a task analysis**: A task analysis is performed by examining all the intended uses of the system from the perspective of both the manufacturer and the user. List all tasks and steps required to accomplish the task. Include any tasks related to any possible misuse of the system in this analysis. When performing the task analysis, at a minimum, consider the following categories:

> machine or process start up
> programming of any machinery PLCs
> commissioning
> all modes of operation
> Interlinked processes such as conveyors, crushers, screens
> operational maintenance such as replacement of GET (ground engaging tools)
> normal and unscheduled stoppages (control failure or jam) and restart and emergency stoppages and restart
> fault-finding and troubleshooting, planned and unplanned maintenance and repair, cleaning and housekeeping.

**Perform a risk appraisal and risk assessment**: Based on the information from the first two steps, perform a risk appraisal and assessment of how workers will be interacting with the system. Outline where possible hazards are, and what the associated risk of each hazard is.

Examples include:

> a hydraulic hose releases pressurised fluid when it is removed for maintenance purposes
> a barrier or guard has been removed or by-passed
> an interlocked gate closes when a worker is in the hazardous area
> a conveyor moves when a blockage is cleared.

**Implement controls**: The controls required will follow what hazards and risks were identified during the appraisal and assessment.

The energy-isolating device can be a manually operated disconnect switch, a circuit breaker, a line valve, or a block. Push buttons, selection switches and other circuit control switches are not considered energy-isolating devices. In most cases, energy-isolating devices will have loops or tabs which can be locked to a stationary item in a safe position (de-energised position).

**Figure 110:** Example of an energy-isolating manually operated disconnect switch with a loop for securing a lockout device (photo courtesy of NZ Steel, Taharoa)

It is good practice to have a process that uniquely identifies all parts of a system including switches, cables, piping and valves. This allows workers to check they are isolating the right energy-isolation device when applying isolation procedures and lock out tag out systems. Make all items readily identifiable and referenced on system plans or diagrams. Permanently label key items of equipment with formal, simple, easily visible and unambiguous labelling wherever mistakes in identification could occur and could result in significant consequences.

**Communication, including training**: Communicate and train appropriate workers on how the procedure works, their role in the procedures, and what their responsibilities are.

## 23.15 APPENDIX O: PERMIT TO WORK SYSTEM PROCESS

An example of a PTW process is:

**Step 1 – Highlight Potential Hazards**: Workers guided by the Supervisor identify potential hazards and implement all necessary safety measures according to the PTW requirements. Work is not permitted to start until Stage 4.

**Step 2 – Application for Permit**: The Supervisor (or Permit Receiver) applies for permission to start work on a prescribed form. The supervisor then submits the application of the PTW to the Authorised Person (or Permit Issuer) only when all the conditions in the PTW have been fulfilled. The Receiver has to indicate in the PTW that risk assessment was conducted for the task and the safety measures to be implemented.

**Step 3 – Evaluation of Permit**: The Permit Issuer evaluates and verifies that all safety conditions specified in the PTW have been fulfilled and adequate. They may also recommend additional measures in the PTW when necessary. They need to inspect the work location where the PTW has been applied for with the Receiver during this process.

Only when all safety requirements stated in the PTW are fulfilled, will the Permit Issuer endorse the PTW form and, if required, forward the permit to the authorised manager.

**Note:** Some companies require an authorised manager to approve work where the initial risk score is at a certain level. For example the task has been risk scored in the High or Extreme category. If this system is not used, Steps 3 and 4 may be done by the Permit Issuer.

**Step 4 – Approval of Permit**: The authorised manager (or Permit Issuer) may approve and issue the PTW only when they are satisfied that:

> proper evaluation of risk and hazards for the work concerned has been conducted

> no incompatible work will be carried out at the same time and location of the PTW which may pose a risk to the persons at work
> all reasonably practicable safety measures have been taken and all persons involved in the work have been informed of the work hazards under the PTW.

Work is permitted to commence on issue or approval of the PTW. The supervisor then posts a copy of the PTW at work location stated in the PTW. The copy will not be removed from the work location until the duration of the PTW has expired or work stated in the PTW has been completed.

**Note:** Permit Receivers and Permit Issuers should not be the same person.

## Notes

## Notes

**DISCLAIMER**

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