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.
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. 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.

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

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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 HSN0 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. 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.

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. 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.

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.

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. 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.

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 signs workers allowed at the blast site
- protection against unintended initiation and how to deal with misfires.

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. 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.

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. 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 done38.
> 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

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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.

**External parties**

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

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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.

### 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 smokey hut, workshop, office or house.

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

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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.


**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.

The approved handler must ensure any misfired charge is identified.

**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.

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43 The Regulations, regulations 86 (k) and (l)
44 Hazardous Substances (Class 1-5 Controls) Regulations 2007, 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 slurry explosive washed out should be treated as deteriorated explosives and dealt with as detailed in section 8.21.

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 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*.  

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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

> 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 charge⁴⁶.

Misfires and other explosive incidents⁴⁷ 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.

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.

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

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 identify 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.
7.3.2 POST EXCAVATION INSPECTION OF BLASTED SECTIONS

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.

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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

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> 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

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.

Scars
Scars 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.

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 PHMP50.

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 overlapping 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 (i.e., 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.

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\(^{51}\) 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.

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.

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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.

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**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\(^\text{54}\) 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.

![Diagram of tip slope stability design](image)

**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.
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.

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.

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.
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 (e.g. 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.

![Vehicle separation at tip point](image1)

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 (i.e., using a backhoe). When material sticks in the tray, no account should be taken of how it is jarring or jamming 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](image2)
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.

8.4 PROCEDURES FOR EXAMINING TIP HEADS

It is critically important to examine a tip head for unsafe conditions on a regular and ongoing 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.

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**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.
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.

8.6.1 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.

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).
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:

- Flags
- 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:

- Radio telephones (RTs)
- Cell phones (where reception allows)

Safety equipment to:

- Ensure the operator is in a safe atmospheric environment if the mobile plant cab is engulfed, and
- Facilitate rescue Devices include:

- Breathing apparatus
- Rescue harness
- Emergency lighting
- 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:

- GPS
- Cameras over draw down points
- Proximity detection
- 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.
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).
Tracks facing the excavation (no more than 45°) to allow rapid exit

Area at risk of under cutting

Potentially unstable ground (distance from toe to rear of mobile plant): Determine working methods based on geotechnical assessment

Figure 47: Dragline working beneath water

Tracks facing the excavation (no more than 45°) to allow rapid exit

Area at risk of under cutting

Potentially unstable ground (distance from toe to rear of mobile plant): Determine working methods based on geotechnical assessment

Figure 48: Long reach excavator working beneath water
Tracks facing the excavation (no more than 45°) to allow rapid exit

Area at risk of under cutting

Potentially unstable ground (distance from toe to rear of mobile plant): Determine working methods based on geotechnical assessment

Escape route

Floating Plant

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

<table>
<thead>
<tr>
<th>VESSEL TYPE</th>
<th>SAFETY SYSTEM</th>
<th>MARITIME RULES RELATING TO DESIGN, CONSTRUCTION AND EQUIPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floating structures that are not navigable, that is they are permanently attached to the shore (eg floating jetties, gangways)</td>
<td>No maritime documentation</td>
<td>Not covered by the <em>Maritime Transport Act</em> or <em>Maritime Rules</em>. Covered by the <em>Building Act</em></td>
</tr>
</tbody>
</table>
| Barges over 24 metres in length | Barge Safety Certificate | Part 40C  
Part 41 may apply  
Part 42A  
Part 42B  
Part 43  
Part 46 Section 3  
Part 47 Section 3  
Part 49 (where there are lifting appliances) |
| Barges less than 24 metres in length | Maritime Operator Safety System (MOSS) | Part 40C  
Part 41 may apply  
Part 42A  
Part 42B  
Part 43  
Part 47 Section 2  
Part 49 (where there are lifting appliances) |
| Barges less than 24 metres in length that do not: | No maritime documentation | Part 40C  
Part 41 may apply  
Part 42A  
Part 42B  
Part 43  
Part 47 Section 2  
Part 49 (where there are lifting appliances) |
|  > Have a lifting device with a WLL of 1 or more tonnes or  
  > Carry passengers (does not include crew)  
  > Carry cargo | Maritime Operator Safety System (MOSS) | Part 40C  
Part 41 may apply  
Part 42A  
Part 42B  
Part 43  
Part 45 (partially apply)  
Part 47  
Part 49 (where there are lifting appliances) |
| All powered vessels | Maritime Operator Safety System (MOSS) | Part 40C  
Part 41 may apply  
Part 42A  
Part 42B  
Part 43  
Part 45 (partially apply)  
Part 47  
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](http://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).

> 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.

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.
> 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.

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.


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.
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.

SEEs 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 person54 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.

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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 (e.g. 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.

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.

Building (Dam Safety) Regulations 2008, regulation 8
The excavator machine should remain on stable ground at all times.

Tracks facing the excavation (no more than 45°) to allow rapid exit.

Allowance for potential break back.

Distance from crest to toe (minimum distances):

<table>
<thead>
<tr>
<th>Height (m)</th>
<th>Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>7.5</td>
</tr>
<tr>
<td>6</td>
<td>9.0</td>
</tr>
<tr>
<td>7</td>
<td>10.5</td>
</tr>
<tr>
<td>8</td>
<td>12.0</td>
</tr>
<tr>
<td>9</td>
<td>13.5</td>
</tr>
<tr>
<td>10</td>
<td>15.0</td>
</tr>
</tbody>
</table>

Distance from crest to toe = 1.5 x height

Height = vertical height of face from toe to crest

Figure 53: Example of cleaning out a settling pond with an excavator.
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.

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.

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.

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](image)

![Figure 55: Example of signage for small sites](image)

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](http://vector.co.nz/safety/near-our-network).

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**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.

![Clearance signage and placement](image)

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\textsuperscript{57}. No single safeguard is likely to be sufficient on its own during reversing. Consider all the relevant precautions together (see Table 8).

<table>
<thead>
<tr>
<th>TYPE OF CONTROL</th>
<th>EXAMPLES OF CONTROLS</th>
</tr>
</thead>
</table>
| Eliminate need to reverse | > Implement one-way systems around site and in loading and unloading areas  
> 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  
> 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  
> 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:  
> allow adequate space for vehicles to manoeuvre safely  
> exclude pedestrians  
> are clearly signed  
> have suitable physical stops to warn drivers they have reached the limit of the safe reversing area  
> Make sure everyone on site understands the vehicle rules  
> Fit all vehicles on site with appropriate warning devices such as reversing alarms  
> Have controlled (or supervised) reversing systems such as the excavator operator controlling the truck coming in to be loaded  
> Use spotters  
> 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.

\textsuperscript{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 (e.g., 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.

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.

![Figure 58: Loading and restricted zones](image)
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 out58.
> 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

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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

> 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. 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.

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58 The Truck Loading Code
59 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 people 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. 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
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 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/highwayworkzones/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

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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 (e.g., 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 (e.g., 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 (e.g., 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 (i.e., 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.

- 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 (i.e., 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.

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[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.