



VERTICAL OPENING DEVELOPMENT IN UNDERGROUND MINES (RISE DEVELOPMENT)

PRELIMINARY

The purpose of this Bulletin is to provide to the mining industry the view of the regulatory authority on the duty of care implications for employers in carrying out vertical development in underground mines.

The terms “rise” and “raise” have the same meaning.

As defined in the MSI Act,

“rise” means a vertical or steeply inclined development opening driven upward from any level in an underground mine.

In this context, any means of vertical development, (other than winzing or shaft sinking operations), is included in the scope of rise development.

An extract from the MSI Act is provided here for ready reference, and some regulations of particular relevance to rise development are also listed.

Mines Safety and Inspection Act

Act Section 9 – Duties of Employers

9. (1) An employer must, so far as is practicable, provide and maintain at a mine a working environment in which that employer’s employees are not exposed to hazards and, in particular, but without limiting the generality of that general obligation, an employer must –

- (a) provide and maintain workplaces, plant, and systems of work of a kind that, so far as is practicable, the employer’s employees are not exposed to hazards; and*
- (b) provide such information, instructions and training to and supervision of employees as is necessary to enable them to perform their work in such a manner that they are not exposed to hazards; and*
- (c) consult and co-operate with safety and health representatives, if any, and other employees at the mine where that employer’s employees work, regarding occupational safety and health at the mine; and*
- (d) where it is not practicable to avoid the presence of hazards at the mine, provide employees with, or otherwise provide for the employees to have, such adequate personal protective clothing and equipment as is practicable to protect them against those hazards, without any cost to the employees.*

Act Section 4 – Interpretation

“practicable” means reasonably practicable having regard, where the context permits, to –

- (a) the severity of any potential injury or harm to health that may be involved and the degree of risk of such injury or harm occurring; and
- (b) the state of knowledge about –
 - (i) the injury or harm to health referred to in paragraph (a); and
 - (ii) the risk of that injury or harm to health occurring; and
 - (iii) means of removing or mitigating the potential injury or harm to health:and
- (c) the availability, suitability, and cost of the means referred to in paragraph (b) (iii):

MSI Act Regulations

4.5	Fall arrest equipment;
4.13	Induction and training of employees;
9.14	Air in underground workplaces;
9.16	Air sources;
9.22	Fumes from blasting;
10.13	Excavations to be kept safe;
10.21	Rise operations;
10.25	Ladderways and footways;
10.27	Procedures when workings are approaching each other
10.28	Geotechnical Considerations
10.35	Vertical opening safety procedures.

Given the obligation under the Act for the employer to provide (among other things) a safe place and system of work, qualified by practicability, the approach taken here is to list the working method options in order of the level of hazard potential to operators, commencing from the least hazardous end of the range.

METHODS OF WORK FOR VERTICAL DEVELOPMENT

1. NON-ENTRY METHODS

These methods require no entry by personnel to the raise during development.

Raise Drilling

^This method eliminates blasting, and no entry to the raise is required by personnel during drilling and reaming. Top and bottom access is required.

Hazards are present in several activities:-

- The operation of the rig during set-up and pull down, and in pilot hole drilling and reaming. Precautions are required during pilot hole breakthrough, and attaching the reaming head.
Equipment is heavy and large forces and energy sources are involved in the processes.
- Changing cutters involves lowering the reaming head with the rod string to the raise bottom. Overhead protection may be required during cutter replacement.
- Precautions are necessary in respect to sludge build up in the raise and in disposal of sludge and cuttings, particularly when transfer in passes is required.
- Bailing of cuttings from the pilot hole using compressed air can result in dust and “sand-blasting” hazards.
- Dust evolved during the reaming process must be properly contained and suppressed.

Up-Hole Raise Drilling

(Also called box-hole boring or blind raise drilling)

- Blasting is eliminated, and no entry to the raise is required during drilling and reaming.
- Top access is not required in conventional applications, but variations exist in which top access is required to attach a reaming head at the top of the raise after drilling a pilot hole from the lower horizon, prior to reaming downward.
- Precautions are essentially similar to those required for raise drilling.

Drop Raising (Long-Hole Winzing)

- This method requires top and bottom access (or at least void space to take the broken rock), and involves drilling and blasting, but does not require entry of personnel during raise development.
- It provides an effective means of holing into a void (such as an open stope) from a higher horizon, for example to act as a fill pass.
- Drilling equipment and techniques, and explosives and initiation systems have been developed to the point where this is an effective and viable method over lengths of 20 to 30 metres, or greater.

Inverse Raising

- A drill and blast method by which a “blind” raise is drilled from the bottom heading and fired in a single blast, as for a development round. Lengths of 12 to 15 metres have been routinely blasted by this method.
- Drilling is done with bar and arm equipment, set up to provide accurate parallel drilling with a drifter.
- Mechanised rigs configured for accurate parallel drilling are also suitable.

- Large reamer holes are required and accurate stabilised drilling is essential for success.
- Again no entry to the raise is needed during development and no top access is required.
- Sufficient volume is required at the base of the raise to accommodate all of the broken rock when blasted.
- Some soft friable rock types may not be amenable to this application.
- Adequate precautions must be taken in carrying out close array drilling overhead.
- As is the case with any operations involving blasting, extreme care is required in establishing safe working procedures. Survey checks must be carried out and break-through precautions applied.
- This method is normally used for cut-off slot rises and similar applications where no personnel are required to enter the rise. If personnel are required to enter or travel in such rises after they are driven, the rise must be scaled and secured and supported by working down from the top, for which process top access is required.

2. ENTRY METHODS

2.1 MECHANISED ACCESS

Alimak Raise Climber

- This system has been in use in Australia since 1960, and over a longer period overseas. Although an entry method involving drill and blast, it affords a high level of protection to the miners travelling up the face after the blast, and a secure work platform at the face. It also provides for powerful air water flushing at the face after the blast and for reliable compressed air ventilation via the climbing rack pipe system.
- It is considered to be the entry method involving the least risk to the miner when the equipment is correctly operated and maintained.

This assessment is qualified by the following considerations.

- The Alimak Raise Climber should not be used in ground conditions such that climbing rack anchorage may be suspect. As for cage rising, the Alimak method should not be used in other than good ground conditions, where the risk of rockfall from the face during travel to the face, (after blasting and clearance with an air/water blast), is reduced to the lowest practicable levels.
- A high standard of drilling and blasting practice is required to ensure a clean face after blasting. The muck pile should be inspected after each blast to assess whether the full round has been pulled.
- The risk of injury from falling rock to persons travelling to the face after each blast increases with the cross-section of the rise, for any given set of ground conditions. It is essential to ensure that adequate strength and penetration resistance is built into the decking above the travel cage, to provide protection against any rocks which may fall during travel to the face.

- The cross-section should be kept down to the least practicable, and if a large opening is required, the rise can be stripped after completion and securely supported by working down from the top access. Where larger cross-sections (for example up to 3m square) are driven in a single pass, a stronger deck can be carried using a double drive unit (with two sets of support struts), ensuring greater protection for the crew when travelling.

Cage Raising (Gig Raising)

- This method has been in common use in Western Australia for many years. It requires top access, but the requirement for a pilot hole allows for forced ventilation via the pilot hole, which is preferable to ventilation from the bottom, as is required for blind raises driven by the open ladder method. The face should be cleaned with an air/water blast from either a steel pipe kept close to the face, or a jet lowered down the pilot hole after blasting which is designed to cover the rise face area. The length of round pulled can be measured down the pilot hole after each blast.
- Cage raising involves a higher level of risk than the alimak raise climber method. One aspect of this is that overhead protection for the miner when travelling to the face is less robust than that afforded by the alimak climber. Moreover, particularly in raises of large cross-section, there is a significant risk of the rope breaking if the cage (gig) is struck by a rock falling from the face or sidewalls above due to the “shock” or “impact” load which may suddenly be applied to the rope. Cage rise diameter must be kept to the minimum practicable, to reduce the potential for rock fall, and the method used only in good ground conditions.

The provision of parallel pilot holes allows for a second winch to be used to access the cage if it becomes jammed, or the primary cable hole collapses on the cage hoist rope, or should any other emergency arise.

2.2 LADDER ACCESS IN OPEN RAISING

- This method of work presents the widest spectrum of hazards and the highest level of associated risks.
- If driven blind, a pilot hole can not be used for ventilation from above, and fume clearance after blasting requires ventilation by compressed air pipe incorporating an air/water blast system. For ventilation of the miner working in the rise, ducting is required. Where long-hole drill rigs are available, all blind raises longer than 5 metres should have a blind pilot hole drilled for the length of the raise. This will assist in getting a clean pull in each blast and reduces the risk of loose rock at the face after the blast.
- Specially designed and installed pipes can be used to provide ventilation instead of pulling up soft ducting. Ventilation can be effected safely with adequate care taken, but any shortfall in equipment and use can create a serious risk, and fatalities have occurred from blasting fumes.
- The major hazards are the risk of being struck by falling rock when returning to the face after blasting, and from falling from the ladders. It is virtually impossible to provide complete security from the risk of injury due to rock fall during re-entry to the face by the miner after blasting in this method of work. The residual risks must be managed accordingly.
- The ergonomics of drilling in a raise from ladders are very poor, and can lead to injury.

CHOICE OF MINING METHOD – BASED ON RISK ASSESSMENT

- Beyond a shadow of doubt the non-entry methods for vertical development present the lowest level of hazards and the most readily controlled spectrum of risks. Raise drilling is well established as the regular method for longer (and larger) raises. A further major benefit from any drilling method (as compared to drill-and-blast methods) is the structural integrity of the completed raise and improved ventilation flow, and rock flow where used as a pass.
- It is also self evident that even where up-hole raise drilling equipment is available, it may not always be practicable, (in terms of scheduling and the capital cost of having more than one unit), to drill all short raises.
- The next preferred option in the hazard scale is inverse raising, or drop raising if top access is available. Capital equipment cost is low, and the methods are proven and established.
- Of the entry methods, which all involve drill-blast, the Alimak system presents the least hazards and the most readily managed risks. It must be noted, however, that strict adherence to correct procedures in both operation and maintenance is essential for safe operation. Care of the rack elements is of particular importance. Full account must be taken of the precautions and limitations listed earlier.
- Cage raising has its limitations and also requires scrupulous attention to good practice. As top access is required it is not considered prudent to use the method for raises longer than 30m. (For longer raises, raise boring or Alimak should be employed).
- Cage raising should not be undertaken in other than good ground conditions.
- The cross-section of the raise should be kept to a minimum and robust overhead protection on the cage is essential.
- When the practicability of the above vertical development methods have been assessed, and ladder raising has been determined to be the only option practicable, (in the legal sense defined in s.4 of the Mines Safety and Inspection Act), then every precaution must be taken. A determination should be made of the viability of dual compartment ladder access raising prior to any decision to implement open ladder raising.
- Each operation and each employer should have a thoroughly documented system of work and inventory of equipment needed, and operating crews fully trained in its use, with regular supervision.
- **The following precautions are considered to be the basic minimum for open-ladder raising**
 - Inclination not to exceed 60° from the horizontal.
 - Cross-section to be as small as practicable consistent with safe use of the equipment; (normally not greater than 1.2^m to 1.5^m square.
 - Length should not exceed an absolute maximum of 20m but in any case should be no longer than can be examined with a strong hand light from the raise entrance.

- A steel pipe air/water blast system is to be maintained in the raise, and used for an adequate period after each blast and before re-entry to the raise. The blast jet is to be directed so as to thoroughly sweep the face and dislodge loose material as well as purging noxious fumes.
- Ventilation to the raise face must be maintained while the miner is working in the rise; soft duct or installed large diameter piping is acceptable.
- If top access is available a bore hole must be provided.
- Safe ventilation practices which conform with regulatory requirements are essential.
- Appropriate fall arrest equipment must be used.
- The standard of construction of ladders and of their installation must be high.
- A safe means of getting equipment up to the raise face is required. Manual handling alone is not acceptable.
- A powerful hand light must be available to inspect the raise after blasting and wash down and before re-entry. A hose with a nozzle and sufficient water pressure to wash the walls of the rise down from a position at the entrance for at least 15 metres up the rise must be provided.
- If inspection after wash down indicates hazardous conditions in the raise, no entry is to be made. The miner will report to the supervisor, and the manager will determine an alternative course of action, which may include drop raising from a higher horizon to intersect the raise.

SUMMARY

In determining practicability of a vertical development methods (in terms of the Mines Safety and Inspection Act obligations) it must be understood that impracticable does not mean inconvenient, or difficult, or achievable but at a higher cost per metre than a safer or slower method.

If open ladder raising is adopted, both the reasons for the decision, and the risk management of the work will need to be documented and justified. Should injury occur, an employer who is unable to verify that these measures have been taken may face the most serious consequences under both the civil and the criminal law.

J M Torlach
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