UNDERGROUND BARRING DOWN AND SCALING

GUIDELINE

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FOREWORD

This Department of Industry and Resources (DoIR) guideline has been issued to assist in the development of procedures relating to scaling of loose or potentially unstable rock in underground metalliferous mines.

It is emphasised that this guideline is not totally inclusive of all factors concerning scaling procedures in an underground metalliferous mine. It may not be totally suited to the specific requirements of every mine.

Comments on and suggestions for improvements to the guidelines are encouraged. The guideline will be revised where appropriate to reflect legislative changes and to accommodate new information, improvements in technology and improvements deriving from operational experience.

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1.0 INTRODUCTION

The objective of this guideline is to provide an outline of a systematic approach to the task of scaling and to identify the issues that should be addressed when carrying out scaling to provide a safe underground work environment.

Scaling, also known as barring down, is a basic skill that every person working underground should understand and be able to **demonstrate** to a minimum level of competence. **Scaling may be described as the art and function of making the ground safe using a scaling bar to locate and remove loose rock from the walls, face and backs of the workplace.** In manual scaling, loose or potentially unstable rock is prised off the rock surface with an appropriate scaling bar. **The ability to correctly "read the ground", or assess the ground conditions, is essential to all people carrying out scaling, no matter how small the area to be scaled.** The importance of the ability to correctly **read the ground** can never be over-emphasised in relation to scaling and ground control in general.

The physical work associated with manual scaling is amongst the **most arduous** underground mining work and can only be done effectively for a comparatively short period of time before rest is required. **A high level of mental and physical alertness is required at all time while scaling.** During rest periods, the person should be **actively observing** the area around where they are standing, **in all directions**, to **look for planes of weakness** in the ground that have the potential to form **unstable blocks or wedges**.

Scaling skills are vital for all people working underground to ensure that their workplace is made and kept safe from loose and/or potentially unstable rock.

Manual scaling is potentially one of the more hazardous activities in underground mining. The person carrying out the scaling is working in close proximity to the rock face and can be exposed to potentially unstable ground that may fall unexpectedly. In addition, the conditions underfoot may be very uneven which can hinder rapid evasive action.

A range of issues need to be considered when scaling, these include:

- Identifying the ground conditions;
- Scaling equipment;
- Scaling procedures;

- Scaling in high headings;
- Scaling in narrow headings; and
- Regular check scaling of main access ways.

Scaling is an on-going process in each workplace with exposed ground that is never finished until the mine closes. No ground should be assumed to be stable until it has been sounded with a scaling bar. Recognising that large potentially unstable blocks may appear and sound stable, other means should be employed to make the area safe where doubt exists.

Ground conditions should be checked using appropriate scaling procedures before starting work and confirmed on a regular basis during the shift in ALL workplaces where ground is exposed.

2.0 LEGISLATIVE REQUIREMENTS (WA)

Reference should be made to relevant legislative provisions of the Mines Safety and Inspection Act 1994 and the Mines Safety and Inspection Regulations 1995.

2.1 Duty of Care

Section 9 of the Mines Safety and Inspection Act 1994 includes obligations on employers to provide and maintain workplaces, plant and systems of work such that employees are not exposed to hazards. Section 10 of the Act requires employees to take reasonable care to ensure their own safety and health, and to avoid adversely affecting the safety and health of others.

2.2 Regulations

Regulation 10.13 of the Mines Safety and Inspection Regulations 1995 states:

Excavations to be kept safe

10.13	The underground manager of an underground mine must ensure that each underground excavation in the mine in which persons work or travel is scaled and maintained in a safe condition.

Regulation 10.28 of the Mines Safety and Inspection Regulations 1995 states, amongst other things, that:

Geotechnical considerations

10.28 (2) The principal employer at, and the manager of, an underground mine must ensure that the following things are done in relation to workplaces, travelways and installations underground in the mine -

(d) appropriate equipment and procedures are used for scaling;

3.0 IDENTIFY THE GROUND CONDITIONS

It should never be assumed that the ground in a workplace is safe unless it has been checked by those working in the area using correct scaling procedures. **All underground workplaces are kept safe by regular, on-going, checking and scaling as required.** This is vital to the safety of all people working underground.

Ground conditions may be identified by:

- **Sight** see if the rock looks to be stable – look for intersecting joints, cracks, zones of weakness in the rock; and
- **Sound** listen for rock noise caused by high stress;

  strike the rock with the moil tip on the bar and listen to the sound the rock makes.

Scaling requires a person to:

- **Evaluate** close-up inspection of the area is required to adequately inspect the ground conditions to determine if the conditions are appropriate for scaling or if other action is required; and

- **Act** take appropriate action to remove the unstable rock by scaling or arrange for other action to be taken, see section 5.0.

Rock stability is controlled by a number of factors including:

- Natural planes of weakness or joints in the rock;
- Rock stress levels;
- Rock mass strength; and
- Blast damage to the rock around the perimeter of the opening.

Natural planes of weakness, or joints, in the rock play a very important part in forming the potentially unstable blocks, wedges and slabs that should be removed by scaling. Before scaling it is vital that the ground be observed for an appropriate period of time to determine the orientation, length, spacing and roughness of the exposed trace of the joints or cracks in the backs, walls or face.

The intersection of two or more joints, rock fractures due to blast damage and/or intact rock failure can form potentially unstable wedges or slabs of varying shapes and sizes. Some of these wedges or slabs may be unstable and on the verge of falling or sliding. These potentially unstable wedges or slabs can be located by sounding the rock with the bar during scaling. The application of water to the backs, walls and face can assist with the visual detection of joints, cracks, etc. The application of **water** to certain ground conditions, eg some highly stressed ground, can cause pieces of rock to **spall off** the areas where the water has been applied.

Key blocks or wedges may be holding a number of other blocks and wedges in place behind or above the exposed face. The removal of the key block may "free up" other blocks or wedges, that were previously held in place by the key blocks, thus triggering the fall of a number of other blocks.

The use of a stope light held from the side and directed at the rock face may provide shadows that highlight the outline of a potentially unstable block or slab that can be removed by scaling.

4.0 SCALING EQUIPMENT

Scaling bars come in a variety of lengths and materials. Bar types include:

- Solid steel hexagonal bar, 1.2 m to 2.4 m long, with tips forged at each end; and
- Hollow aluminium tubes, 2.4 m to 3.6 m long, with steel tips securely attached to each end.

One end or tip of the bar has a straight chisel point, the other end has a heel and chisel point toe to give greater leverage.

Generally, solid steel bars are shorter than the aluminium bars because they are heavier. The longer aluminium bars may be preferred in areas with high backs because the operator can stand further away from the potential rock fall. However, hollow bars are not as effective for sounding and are more flexible than a solid hexagonal steel bar. This can make their use awkward or impractical particularly in confined spaces and in high headings.

In ALL workplaces more than 3.5 m high, appropriate purpose designed and built equipment should be used to access the backs and upper areas of the walls and face when ever manual scaling is being carried out.

A variety of other equipment may also be used for mechanised scaling, including:

- Rock drilling jumbos; and
- Mechanical scaling units.

It is important to recognise that rock drill jumbos have NOT been specifically designed for the purpose of scaling. It is understood that these machines are sometimes being used for scaling or rehabilitation purposes, however their **limitations** with respect to scaling should be recognised and understood by all operators and mine management.

Regardless of the method used for initial scaling, MANUAL SCALING should be the FINAL means of scaling in ALL workplaces.

The bucket of a load-haul-dump unit (loader) should NOT be used for scaling.

5.0 MANUAL SCALING PROCEDURES

5.1 Introduction

Before commencing manual scaling you should **have and be using**, where appropriate, the required personal protective equipment including: gloves, safety glasses, safety helmet, cap lamp, self rescuer, protective clothing (long sleeved), safety boots, hearing protection and safety rope and harness if there is a potential for the person to slip or fall.

It is also necessary to ensure that the **workplace ventilation is operating and is adequate** to dilute and disperse fumes and dust and that the area has been **thoroughly watered down** particularly after blasting.

Scaling bars are used to lever or prise loose rocks off the backs, walls or face. The tip is inserted into joints or cracks in the rock. Using the procedures, summarised below, loose potentially unstable rock can be removed with the minimum risk to the person involved.

The rock surface is regularly tapped firmly with the bar tip (sounded) to identify loose rock. Good ground will tend to make a high pitched ringing sound when tapped with the bar. **Bad or suspect ground will generally tend to make a hollow, lower pitched, dull thud or drummy sound when struck with the bar tip.**

5.2 Large potentially unstable blocks

In some circumstances, very large, potentially unstable, block(s) or wedge(s) may NOT make a hollow or drummy sound when vigorously struck with a bar tip. In these situations the prudent course of action should be to:

- Use a **mechanised scaling unit** that has been specifically designed and built for mechanised scaling work in underground mines; or

- **Bore stripping holes** above and if necessary into the large potentially unstable block using a **method of remote drilling**, charge the holes with explosives and fire down the block(s); or
- Install **adequate ground support and reinforcement** into the potentially unstable block using a **REMOTE means of DRILLING and INSTALLING** the ground support and reinforcement.

5.3 Ravelling ground conditions

Some ground conditions are such that they can be scaled for a very long time before they may ultimately reach a stable arch shape. Some examples of this ravelling condition may include very closely jointed, blocky ground and some very low strength, sheared ultramafic rocks. The ground conditions may be such as to produce the fall of a large number of rocks as soon as scaling commences. In these situations extremely hazardous conditions or excessively long scaling times may exist. Manual scaling under these conditions is extremely hazardous and should not be undertaken.

The techniques for managing this situation include:

- Where possible avoid mining in these types of ground conditions - this requires a knowledge of the ground conditions ahead of mining;
- Use mechanised scaling equipment to remove the larger potentially unstable material; and then
- Apply shotcrete to the freshly exposed rock surface soon after the blast as possible (generally before any broken rock is loaded out of the heading or stope).
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5.4 Progressive scaling and support

Excavations should be **scaled and supported progressively** in a systematic manner having due regard for the prevailing ground conditions. **Large areas of backs should not be scaled before the installation of appropriate rock support and reinforcement commences.** The exposure of employees to large areas of unsupported scaled backs is a potentially hazardous situation in most ground

conditions. The removal of key block(s) during the scaling process may result in major falls of ground, particularly in wide excavations.

The progressive installation of rock support and reinforcement promotes the development of arching forces that assist in stabilizing the rock, particularly where large back areas are exposed. The development of these arching forces necessarily requires slight inward movements of the rock mass into the excavated void. The installed rock support and reinforcement plays a **vital role** in limiting movement on planes of weakness in the rock mass. If the rock support and reinforcement is not progressively installed, the full development of these arching forces is unlikely to occur and the excavation is potentially unstable.

Systematic scaling with the progressive installation of rock support and reinforcement are considered to be one of the basic fundamentals of sound mining practice.

5.5 Scaling procedures

When using a scaling bar always follow the correct procedures which can be summarised in the following five points:

- USE A BAR OF THE CORRECT LENGTH AND IN GOOD CONDITION
- HAVE A FIRM FOOTING AND A CLEAR SAFE RETREAT
- SCALE FROM GOOD GROUND TO BAD GROUND
- WATCH FOR UNEXPECTED FALLS
- DROP THE BAR IF A ROCK FALLS TOWARDS YOU

If the **area cannot be made safe** by manual scaling or if the suspect area cannot be reached effectively using the longest bar available, **barricade access** to the area by use of **appropriate warning signs** and **report to the supervisor** so that **alternative means of making safe** can be used, eg mechanised scaling, stripping or ground support and reinforcement.

5.5.1 Bar

Use a bar of the correct length and in good condition

The correct length bar that is straight and has sharp tips **should** be used for scaling. The bar should be long enough to safely reach the area to be scaled. In workplaces less than 3.5 m high manual scaling can be done by most people of average height using a 2.4 m long scaling bar.

In high headings, ie those headings more than 3.5 m high, where a normal length bar will not allow the backs to be reached, other means should be used to reach the backs for inspection and scaling. These are discussed in section 6.

When scaling, NEVER hold the bar in front of you when scaling. A sudden fall of rock could result in the bar being pushed against you and cause an injury.

When levering a rock from the back, it is better to **push or pull the bar in an upward direction** as there is less chance of loosing your balance and stumbling into the danger area if the rock falls suddenly. Similarly, when levering a rock from the side walls or face, it is better to push or pull the bar in an upward direction where ever possible to minimise a loss of balance.

5.5.2 Footing and retreat

Have a firm footing and a clear safe retreat

Have a firm footing before starting to scale. Always plan the scaling of the suspect area. Never just "barge in" and start. Know where you are standing and ensure the immediate area is clear of obstacles.

Check that the area behind you is clear so that you can move back quickly if required. Remember when scaling, as you work towards the face, rocks that have come down will become obstacles in your retreat path, so continuously observe and plan your retreat route.

5.5.3 Scaling direction

Scale from good ground to bad ground

Plan your approach so that you are always working under ground which you have already scaled and checked and if necessary had supported. **Never assume the ground in a workplace is safe.** Scale the back first, then the sides progressively from the top of the walls down.

Do not use a pick to scale the walls or face above shoulder height.

Do not over reach when scaling, especially near open holes.

5.5.4 Unexpected falls

Watch for unexpected falls

Never assume an area will remain stable after it has been scaled. Regularly check the working area before commencing work and during the working shift. Exposure of the ground to air, water and changing rock pressure or stress, caused for example by drilling activities for blasting or the installation of rock reinforcement, will tend to loosen the ground. Loose ground may fall without warning.

5.5.5 Evasive action

Drop the bar if a rock falls toward you

Be prepared for rock falls to happen at any time when scaling. If this does occur, be prepared to drop the bar and retreat quickly to avoid injury from the bar, the rock or obstacles on the floor.

6.0 SCALING IN HIGH HEADINGS

6.1 Manual scaling from a work platform

When manual scaling is to be done in areas where the backs, walls or face cannot be reached comfortably when standing on the floor, other safe means should be used to permit inspection and scaling to be carried out. A **high heading** situation is considered to exist when the standard length bar (usually 1.8 to 2.4 m long) cannot be used effectively and comfortably to scale the backs when standing on the floor. **A high heading is any heading more than 3.5 m in height.** It is strongly

recommended that **additional lighting should be provided and used** to supplement the cap lamp when inspecting the backs, walls or face in a high heading.

The methods used to reach the high backs, etc should be robustly designed to cope with scaling conditions. Rock falls may accidentally apply large impact forces to equipment during scaling. The equipment used to provide access to the high areas should be sufficiently strong and robust to withstand these large sudden dynamic loads. Some access methods that may be suitable for these conditions include:

- Work platform (purpose designed and built) securely attached to a loader bucket;
- Work platform (purpose designed and built) mounted on an articulated or telescopic boom on a diesel unit; or
- Work platform (purpose designed and built) mounted on a scissor lift unit.

Scaling from a loader bucket is not a safe work practice and should NOT be done.

When scaling near operating diesel powered equipment the noise from the engine or engines will tend to make sounding the rock much more difficult due to the higher noise levels. Precautions should be taken to ensure a minimum level of equipment noise when sounding the backs, walls or face of the workplace.

Prior to conducting manual scaling from a work platform it is recommended that the following issues should be addressed:

- Ground conditions;
- Position of the loader or service unit when it is parked in an excavation;
- Duties and training of the operator at the controls of the vehicle;
- Means of communication to be used by the people involved;
- Means of entry to and exit from the work platform;
- Amount of lighting required to adequately inspect the backs, walls and face;
- Scaling procedures and rules that will apply when scaling from the work platform;
- Design and construction of the work platform;
- Means used to correctly and securely attach the work platform to the service unit;

- Requirement to prevent rapid descent of the work platform following damage to or failure of the hydraulic system (see AS 1418.10 - 1996);
- Position of person in the work platform whilst it is being raised or lowered;
- Condition of the work platform floor;
- Tramming of the work platform;
- Positions of people on the service unit and the work platform when tramming;
- General operation of the service unit; and
- Maximum number of people permitted in the work platform at one time.

Each mine should **develop** its own **work procedures for manual scaling from a work platform** to suit its unique combination of ground conditions, heading geometry, equipment and mining method(s).

6.2 Drill jumbos

A large number of mines in WA use drill jumbos to remove rock from the excavation perimeter. Phrases such as "rattling the backs", "dollying the backs", "power scaling", etc are used to describe the process of using a drill jumbo to "scale" a rock surface. This attempt to "scale" is used in areas with high backs, walls or face that cannot be reached from the floor by manual scaling.

The drill bit is run on to the rock surface, with the drifter operating, and drilled into the rock a short distance. Alternatively, the drifter feed and/or boom hydraulics may be used to rake the bit across the rock surface, with the drifter operating. Both approaches attempt to dislodge any loose rock **using the drill jumbo in a manner for which it was not designed**. These methods use the power of the drifter and the boom hydraulics to provide large impact forces in an attempt to dislodge potentially loose rock in a **very indiscriminate** manner. The **angle at which these large impact forces can be applied** to the rock surface **is restricted** by boom length and geometry relative to the size of the excavation and may not be the optimum angle required to dislodge the material.

No effort is made to sound the area to detect potentially loose material. As a result **pieces of loose rock may be left** on the backs or walls presenting a potential hazard in an area that has apparently been scaled. The high noise levels produced

when rattling the backs, etc **do not allow the correct sounding procedures** to be carried out to check for loose rock.

It should be clearly recognised by all concerned that the booms and drifters of conventional drilling jumbos have NOT been designed and built to be used for scaling.
Substantial damage to boom components regularly result from this activity.

Manufacturers, importers, suppliers of drill jumbos are reminded of Section 14 of the Mines Safety and Inspection Act 1994, which, amongst other things, states:

Duties of Manufacturers etc.		
14.	(1)	A person who designs, manufacturers, imports or supplies any plant for use at a mine must, so far as is practicable -
	(a)	ensure that the design and construction of the plant is such that persons who properly install, maintain or use the plant are not, in doing so, exposed to hazards;

Plant is defined in the above Act as:

"plant" includes machinery, equipment, appliance, implement, or tool and any component or fitting of or accessory to any such article.
If the **principal employer and the manager** determine that jumbo scaling of the backs, walls and face of the workplace is an appropriate method of work, they should be able to **justify** why it is considered to be a **safe work practice**, having regard for:

- Ground conditions;
- Size of the excavation;
- Suitability of the equipment for the purpose of scaling;
- Alternative methods of scaling;
- Hazards to the workforce; and
- Quality of the mining practices, particularly the **drilling and blasting aspects**.

The importance of using the appropriate drilling and blasting practices cannot be over-emphasised. The use of **controlled drilling and blasting techniques** is considered to be vital to reducing excessive rock damage from blasting. **The lack of half hole barrels visible in the backs and side walls of many excavations is clear evidence that considerably more needs to be done to reduce un-**

necessary damage to the rock mass. This should greatly reduce the need for reshaping the excavation perimeter with the drill bit.

Each mine should **develop** its own **work procedures for scaling** to suit its unique combination of ground conditions, drilling and blasting techniques, heading geometry, equipment and mining method(s).

6.3 Mechanised scaling

The more widespread use of purpose designed and built mechanised scaling units is encouraged. These robust units have been specifically designed for heavy duty work in the hazardous role of removing potentially unstable blocks from wide and/or high excavations. **The use of mechanised scaling equipment should be an integral part of the mining cycle.**

The over-reliance on development jumbos to perform up to three unit operations in the mining cycle for which they were not designed, ie charging-up, scaling and rock bolting, should be recognised as lacking the necessary operational flexibility for efficient high speed development advance. Rock fall damage to these high capital cost items of equipment can halt mining advance with adverse implications for contract payments.

Single heading advance requires a high level of equipment co-ordination, availability and utilization, however this should **not** be used as an excuse for not using mechanised scaling. Multiple heading advance provides considerably more operational flexibility, particularly with multi-skilled mining crews, such that different pieces of equipment can be **productively employed** in different headings in various parts of the mining cycle.

A comprehensive review of **all the direct and indirect costs** associated with:

- Excessive use of drilling consumables (bits, rods, couplings, adaptors, etc);
- Maintenance of jumbo booms damaged by rock falls;
- Loss of productive work due to jumbo unavailability caused by rock fall damage; and

- Loss of development advance or tonnes broken by jumbo being used for non-drilling activities (eg scaling, charging-up and rock bolting); should provide great incentive for more active consideration of mechanised scaling equipment.

Prior to using mechanised scaling it is recommended that a range of issues should be addressed including:

- Ground conditions;
- Size of excavations where the equipment is intended for use;
- Ensure that **controlled drilling and blasting practices** are being used in all development headings and stopes;
- Arrange for regular and on-going training of all the people who will operate and maintain the mechanised scaling unit;
- Review operation and maintenance of the unit on a regular basis by involving **all** concerned with its use and maintenance;
- Availability of spare parts; and
- Experience of other mining operations with similar items of equipment.

Each mine should **develop** its own **work procedures for mechanised scaling** to suit its unique combination of ground conditions, drilling and blasting techniques, heading geometry, equipment and mining method(s).

7.0 MANUAL SCALING IN NARROW HEADINGS

The application of appropriate scaling procedures in narrow stopes or development headings raises a number of issues that should be addressed. Confined working conditions in narrow headings can be found in situations ranging from wide flat dipping stopes to narrow ladder rises.

In **narrow flat dipping stopes**, approximately 1 m high, where the footwall dip is much less than the ore rill angle, it is necessary to traverse the stope in a crouched or kneeling position. This position restricts the free movement of the person doing the scaling and may reduce the effectiveness of scaling.

In a **narrow unfilled slot stopes**, where the footwall dip exceeds 35^{o} to 40^{o} (ore rill angle), the ability to move around freely in the stope is hindered by the requirement to use a safety rope. The requirement to use a safety rope in a steeply dipping unfilled stope would also tend to reduce the effectiveness of scaling.

In **narrow ladder rises** the ability to clearly and adequately observe, reach and scale the face, from a **safe position**, is made more difficult by the length, inclination and straightness of the rise.

The issues that should be recognised and addressed when scaling in narrow headings, ranging from flat dipping narrow stopes to steep ladder rises, include:

- Ground conditions;
- Confined working environment;
- Secure footing with the use of a safety rope where there is a danger of the person slipping or falling;
- Adequate illumination;
- Adequate inspection of the face, walls and backs from a **safe area**;
- Adequate sounding of the backs, walls or face as required from a **safe area**; and
- Use of standard scaling procedures.

Each mine should **develop** its own **work procedures for scaling narrow headings** to suit its unique combination of ground conditions, heading geometry, equipment and mining method(s).

8.0 REGULAR SCALING OF MAIN ACCESS WAYS

Ground conditions in an area can **change** with time for a number of reasons including:

- Vibrations from drilling and blasting operations;
- Groundwater or water from stope filling operations (hydraulic fill);
- Time dependent behaviour of the rock (this issue is often not well understood); and
- Changes in rock stress levels caused by the removal of ore or rock from nearby stopes or development headings.

Consequently, it should **not** be assumed that the ground conditions in any excavation will remain as good as they may have been when the access was first mined, scaled and supported. The use of the main access ways by a large number of employees, each shift, results in a considerable exposure of the workforce to these ground conditions. The risk of injury to an employee occurring, if a rock fall takes place in the main access way, is higher because more people use the access way.

Regular scaling of all main access ways is considered to be an appropriate method of ensuring that the risk of unexpected rock falls is minimised. The frequency of check scaling is dependent on the local ground conditions and nearby mining activity. A thorough close-up inspection of the backs and walls of the main access ways is essential to ensure the safety of those travelling in the mine. The sections of the main access ways that have been scaled should be permanently recorded with details of the areas checked, adverse ground conditions encountered, the date and any remedial action taken.

Where total coverage of the rock surface exists (eg concrete lining, shotcrete, timber sets and lagging, rock bolts and mesh, etc) common sense action is required to check the integrity of the lining for signs of deterioration, corrosion, etc. Sounding of shotcrete with a bar or geology pick may be an effective means of checking its integrity.

9.0 ACKNOWLEDGMENTS

The DoIR acknowledges that the information presented in this guideline has derived from a number of sources including a Mount Isa Mines Limited (1991) booklet, as well as Mining Operations Division staff.

Additional information on scaling issues may be found in *SAFE MINING* - CCH/ANZMEC/MCA (1996):

- Underground excavations, page 43-250.
- Loaders as elevated work platforms, page 48-450.

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