Guideline for Raiseboring Operations

MDG 1030

Produced by Mine Safety Operations Division,

New South Wales Department of Primary Industries

June 2003

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

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We wish to thank the Metalliferous Safety Advisory Committee and the Coal Safety Advisory Committee for their most welcome support of this publication.

DISCLAIMER

The compilation of information contained in this document relies upon material and data derived from a number of third party sources and is intended as a guide only in devising risk and safety management systems for the working of mines and is not designed to replace or be used instead of an appropriately designed safety management plan for each individual mine. Users should rely on their own advice, skills and experience in applying risk and safety management systems in individual workplaces.

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FOREWORD

The Department of Mineral Resources document MDG 1030 TR – *Technical Reference Material for Raiseboring Operations* is attached to this Guideline. It provides supporting reference material.

This is a Published Guideline. Further information on the status of a Published Guideline in the range of OHS instruments is available through the Department of Mineral Resources Legislation Update Number 2/2001 which is appended to this Guideline.

The range of instruments include:

- Acts of Parliament
- Regulations made under the Act
- Conditions of Exemption or Approval *(Coal Mines)*
- Standards (AS, ISO, IEC)
- Approved Industry Codes of Practice (under the OHS Act)
- Applied Codes, Applied Guidelines or Standards (under clause 14 of the Coal Mines (General) Regulation 1999)
- Published Guidelines
- Guidance Notes
- Technical Reference documents
- Safety Alerts

The principles stated in this document are intended as general Guidelines only for the assistance of owners and managers in devising safety standards for the working of mines. Owners and managers should rely upon their own advice, skills and experience in applying safety standards to be observed in individual workplaces.

The State of New South Wales and its officers or agents including individual authors or editors will not be held liable for any loss or damage whatsoever (including liability for negligence and consequential losses) suffered by any person acting in reliance or purported reliance upon this Guideline.

The MDG1030, *Guideline for Raiseboring Operations,* was distributed to industry for consultation and comment through a representative working group, the Metalliferous Safety Advisory Committee and the Coal Safety Advisory Committee.

The Department of Mineral Resources has a review time set for each Guideline that it publishes. This can be brought forward if required. Input and comment from industry representatives would be much appreciated. The Feedback Sheet at the end of this document can be used to provide input and comment.

R. Regan
Chief Inspector

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Purpose and scope

This Guideline is intended to assist mine managers and contractors in the implementation of safe systems of work during the raiseboring of shafts, raises and service holes of any diameter and in any location or configuration.

The scope of this Guideline includes the initial planning and design of the project as well as the actual operational aspects of raiseboring.

Where raiseboring projects are subject to competitive tendering to specialist providers, this Guideline provides mine managers with an opportunity to base pre-selection of tenderers on a demonstrated understanding and commitment to addressing hazards identified in this Guideline.

Note that

- Adherence to Guidelines does not of itself assure compliance with the general Duty of Care.
- Mine operators deviating from Guidelines should document a risk assessment supporting the alternative arrangements.

References

Legislation

- Occupational Health and Safety Act 2000, general Duty of Care
- Clause 46 of the Mines Inspection Act 1901 requires the general manager to ensure that any foreseeable risks to the health & safety of persons at the mine are identified and assessed and that such risks are eliminated or minimised to the fullest extent that is reasonably practicable
- Clause 9 of the Mines Inspection Act, General Rule 2000 requires the general manager to prepare, communicate and regularly review a mine safety management plan
- Clause 11 of the Mines Inspection Act, General Rule 2000 requires the contractor to comply with a mine safety management plan which is approved by the general manager
- Clause 37, Coal Mines Regulation Act 1982, Manager to have full charge and control of operations at a mine
- Part 13, Clauses 187-197 Coal Mines (Underground) Regulation 1999, Sinking of Shafts

NSW Department of Mineral Resources publications

- MDG 1010 Risk Management Handbook
- MDG 1015 Guideline for Mobile and Transportable Equipment in Mines
- Minerals Industry Safety Handbook – July 2002
- Mine Safety Management Plan Workbook

Standards

- AS 4360 - Risk management
- AS 4133.3.4 – 1993 Methods for testing rocks for engineering purposes – Rock swelling and slake durability tests – Determination of the slake durability index of rock samples
- AS 4133.4.1 – 1993 Methods for testing rocks for engineering purposes – Rock strength tests – Determination of point load strength index
- AS 4133.4.2 – 1993 Methods for testing rocks for engineering purposes – Rock strength tests – Determination of uniaxial compressive tests

Other references

- McCraken A., T.R.Stacey – *Geotechnical risk assessment for large diameter raisebored shafts.* Trans. Inst. Min. Met. Sect. A, 98, September December 1989
- Anderson K. *Geotechnical Assessment Guide for Raise Boring Site Selection.* Australian Raise Drilling Pty Ltd (unpublished)
- *Raise Boring Index Testing.* In Raise Bore Manager, Tamrock, Finland
- Draft ISRM *Suggested Method for Determining of Hardness Index of Rock Materials.* Int. J. Rock Mech. Min. Sci. Vol 35. No 6 pp. 831-835, 1998.
- ISRM *Suggested Method for Determining Tensile Strength of Rock Materials.* Int. J. Rock Mech. Min. Sci. Vol 15. No 3 pp. 99 -103, 1978
- Draft ISRM *Suggested Method for Determination Hardness and Abrasiveness of Rocks. Int.* J. Rock Mech. Min. Sci.
- *The Raise Boring Handbook* – Second edition 1997 – Atlas Copco Robins
- *'The safe work practice of changing out a raisebore reaming head underground'* - Amalg Resources, Eloise Copper Mine – 2002 finalists – Minerals Council of Australia Innovation Awards.

- *High Grade Uranium Mining at McArthur River, Saskatchewan, Canada* – D. Beattie and T. Davis: AusIMM 8th Underground Operators' Conference July 2002

Raiseboring management system

General

Management systems for raiseboring should be integrated with the Mine Safety Management Plan (MSMP) and be based on a risk management approach to safety. Users of this Guideline should refer to MDG 1010 *Risk Management Handbook* for more information on this approach.

Systems and procedures for each of the design, management and operational steps identified in this Guideline should, where appropriate, be developed in consultation with contractors, employees and their representatives.

The technical reference document appended to this Guideline identifies hazards and controls. These should be considered when developing hazard controls and safe systems of work for raiseboring projects.

The contents of this Guideline are structured to meet the requirements of contracted raiseborer services. Should a mine provide and operate raiseborers in-house, then any risks identified for contractors in the Guideline should be included in the development of the mine's own Mine Safety Management Plan.

Procedures for monitoring and evaluating the entire raiseboring process should be developed as an initial part of developing systems and procedures. That is, no system/procedure is complete without a monitoring, evaluation and review component.

Record keeping and documentation

The records and documentation of the design, planning, contract development (if applicable) and operation of a raiseborer should be integrated with the MSMP document control system. Accurate records should be kept of all stages of the raiseboring project, from the design stage to commissioning. Particular documents that can be considered may include:

- documented risk assessments associated with the mine planning/hole design, geotechnical assessment, groundwater, gas, provision of operational services, site mobilisation, pilot hole drilling, rod handling, reamer assembly/attachment, reamer collaring, cuttings removal, cutter inspections/changes, removal of reamers and demobilisation
- design parameters and specifications of equipment
- Safe Work Procedures for all high risk activities
- records of nominated responsibilities
- records of relevant geological mapping, drill logs and any resultant interpretation
- records of any actual water or gas ingress in the planned hole location or area of influence
- testing and maintenance of equipment including mobile equipment, the raiseborer, power packs and compressors, drill strings, raiseborer heads and cutters, lifting gear and ancillary equipment
- drilling and reaming reports
- records of training
- records of workplace inspections
- records of hazard reporting and follow up

Training

The Mine Safety Management Plan should include a training plan that ensures all employees are trained and competent to perform the tasks required of them. Training should include a documented training assessment. This may be a component of Safe Work Procedure competency assessment.

Particular attention should be given to ensuring that all personnel working on raiseboring projects are made aware of the correct use and limitations of all equipment they use.

Section 11 of the Mines Inspection Act 1901, General Rule 2000 provides the compliance requirements and Mine Safety Management Plan development options for metalliferous mine general managers and contractors should a contractor(s) be engaged for a raiseboring project.

Training and skills should be recorded on personnel files.

Monitoring, systems audit and review

The raiseboring process, from design to commissioning, should include a monitoring and review process to ensure all required procedures and standards are being complied with. This auditing and review should be part of the continuous improvement process under the Mine Safety Management Plan. This includes action to:

- monitor record keeping
- audit procedural compliance
- audit implementation of remedial action from hazard identification
- analyse results, both routinely and after special occurrences or problems
- feed outcomes from analysis back into future planning and operations
- integrate the monitoring and review of raiseboring into the Mine Safety Management Plan review and continuous improvement process.

Risk identification and assessment

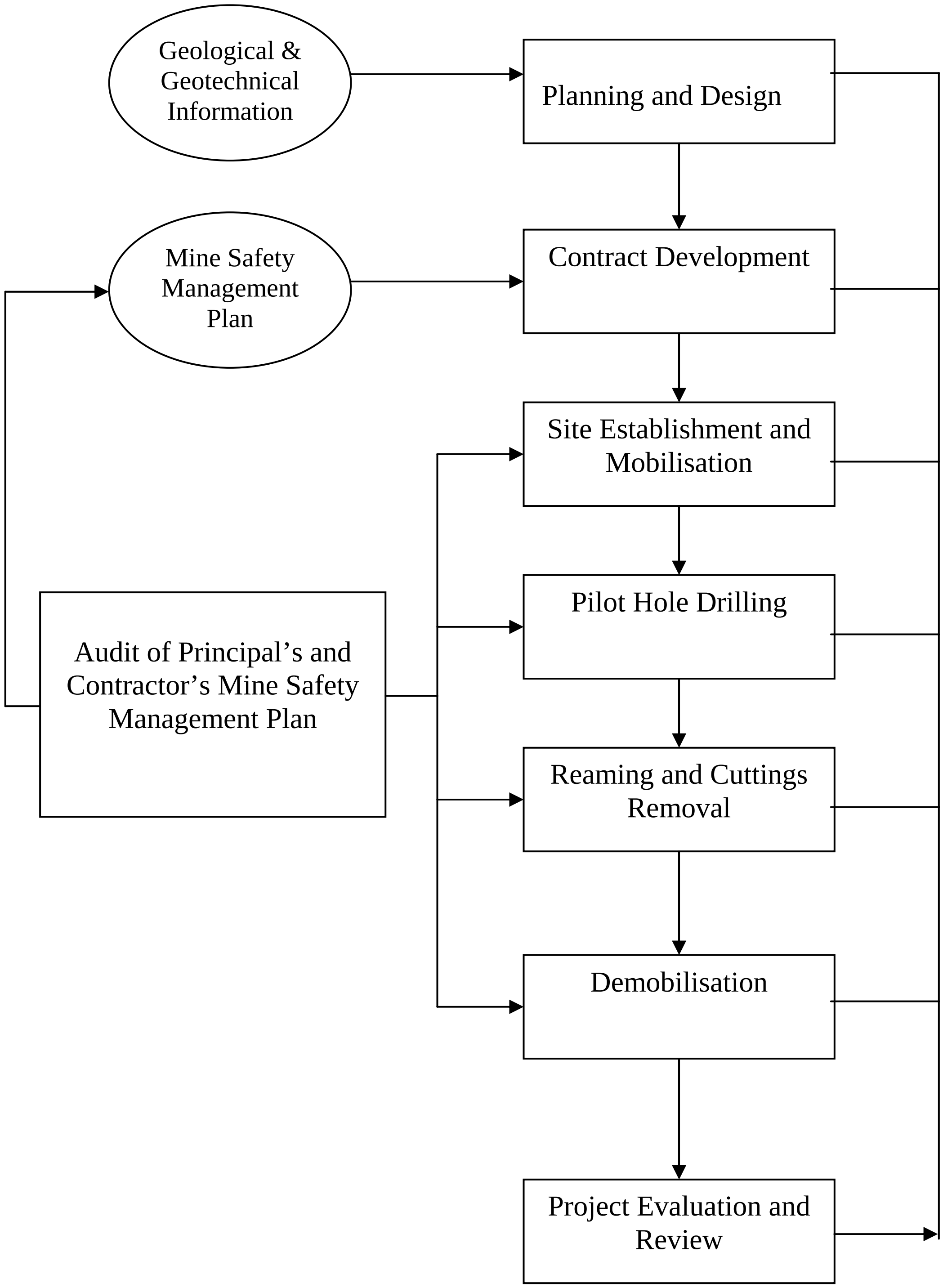
The following section lists the main hazards associated with the raiseboring process and outlines some of the controls currently used in the industry to address them.

These lists are not exhaustive. There may be other hazards, including site specific hazards, which must be identified and controlled.

The *Technical Reference Material for Raiseboring Operations* - MDG 1030 TR is attached to this Guideline. It provides supporting reference material and tables the key system components, issues to be considered and possible controls.

For more information on how to conduct a risk assessment refer to MDG 1010 *Risk Management Handbook*.

The Raiseboring Process



Raiseboring operations system – elements and considerations

Planning and Design

Required outcomes

A raisebore hole design which meets the design purpose for the duration of the planned life of the hole and incorporates consideration of hole location, length, inclination and diameter, ground conditions, water and gas occurrences, ventilation and drillability to achieve a stable excavation.

Main risks

- hole fails as a result of inadequate determination and review of geological and geotechnical information
- unplanned ingress of water or gas, poor ground and/or inadequate provision of services
- premature cutter failure due to incorrect estimation of the drillability or unpredicted failure of the rock mass
- cutters fail due to adverse hole geometry (diameter, length, direction and inclination) contributing to increased wear rate or stress
- unplanned project delays which can transpire into delays to the work program and unsafe work practices in order to deal with them
- non-compliant ventilation conditions following breakthrough caused by unexpected air flows
- unplanned breakthrough into existing workings
- unpredicted methane emission in coal mines following reduced mine ventilation pressure on hole breakthrough. There is potentially increased risk if the raisebored hole is a ventilation shaft to surface.

Main risk considerations

- determination of predicted ground conditions parameters is established and defined by industry standards
- evaluation of geological and geotechnical parameters is conducted by competent person(s)
- conditions of the rock mass and rock properties are known prior to 'sign off' on hole design
- where design options allow, risks associated with non vertical, longer or larger diameter holes are minimised
- designs avoid known poor ground
- designs avoid unplanned hole breakthroughs due to inadequate hole design, checking for existing excavations or providing insufficient clearance to accommodate potential hole deviation.
- selection and configuration of cutters to reflect an assessment of drillability, geological structures and discontinuity
- safe work procedures non compliances occur because the Mine Safety Management Plan is not effectively managed. 'Short cuts' are taken to eliminate or minimise unplanned project delays
- unplanned events caused by inadequate provision of project services (auxiliary ventilation, electrical power, lighting, compressed air, drainage, pumping, cuttings handling / disposal)
- ventilation plans and ventilation infrastructure are adequately designed and prepared prior to breakthrough
- methane occurrences in coal mines are monitored throughout the pilot hole drilling and reaming phases of the project
- forced in-hole ventilation is provided to disperse methane
- the potential for frictional ignition of coal dust is included in control measures
- design specifications for lifting points and civil works are included in the project tender invitation.

Contract Development

Required outcomes

A negotiated contract that is accurately scoped and includes systems that have identified and risk ranked potential hazards with appropriate actions to control them. A contract which is fully scoped and completed prior to project commencement, and is auditable throughout the contract term. A contract which minimises the likelihood of surprises which may adversely affect the safety performance of either party.

Main risks

- the tender invitation scope does not adequately identify hazards. Therefore, hazard control provisions have not been made in the pricing which can result in risk taking
- an inadequate and /or non-compliant Mine Safety Management Plan
- geological and geotechnical information is not available at the time of tendering, or is incomplete or inaccurate

- the contractor has not developed adequate systems to manage safety and health
- the principal has not developed adequate systems to manage safety and health
- the project schedule does not include provision for establishing and managing safety and health systems

Main risk considerations

- the contract tender scope is prepared prior to commencement of contract negotiations
- the contract scope addresses all identified risks associated with the project
- the tender document addresses all risks identified in the contract scope
- a contractor's Safety Management Plan is approved by the general manager or the contractor agrees to follow the mine's Mine Safety Management Plan (*ref MIA General Rule 2000 Clause 11)*
- comprehensive safety and health systems are developed and communicated prior to project commencement
- assessment of contractors' safety and health systems are included in a formal tender evaluation
- auditing of relevant contractor's and principal's safety and health systems are included in the conditions of contract

Site Establishment & Mobilisation

Required outcomes

A raiseborer project in which the provision and application of necessary site works and infrastructure does not increase the risk of injury to personnel or adversely impact on the effectiveness or efficiency of the project.

Main risks

- the design, planning and mining of excavations and the equipping of raiseborer chambers and/or breakthrough positions is inadequate
- the raiseborer chamber is not designed or configured for safe operation of the installed equipment
- lifting points and associated equipment do not meet engineering design standards
- civil works are not designed or constructed to industry standards
- the specification or maintenance condition of installed equipment is not fit for purpose
- risks associated with the transportation of equipment and ancillary gear are not adequately identified or addressed
- the delivery sequence of equipment to the raiseborer site / chamber site has not been adequately planned

Main risk considerations

- consult contractors and raiseborer operators in the design and standardisation of raisebore chambers and breakthrough positions.
- include standard mine designs for raiseborer chambers with the tender invitation documentation
- prior to being used at the mine, ensure competent persons conduct mechanical and electrical inspections of equipment and ancillary gear to establish that they are 'fit for purpose' and meet an appropriate standard
- ensure equipment is subjected to an appropriate and effective maintenance plan
- communicate raiseboring machine and ancillary equipment specifications to relevant engineers prior to the design of associated mine excavations and scheduling of power and other installed services
- deliver equipment to the raiseborer site in a planned sequence to minimise risks associated with rehandling, inappropriate storage and work area constraints
- document and communicate risk assessments and resultant controls identified during transportation of equipment and ancillary gear to the worksite(s) prior to work commencing
- ensure lifting points required during equipment transportation and installation are designed and installed to demonstrable engineering standards
- ensure adequate rod storage and handling facilities are included in the project design

Pilot Hole Drilling

Required outcomes

A pilot hole which breaks through on schedule, to the planned location and without damage to installed services or increased risks to persons from falls of ground.

Main risks

- pilot hole misses target – potential breakthrough into other workings and/or unplanned project delays
- pilot hole breaks through into unplanned location due to excessive hole misalignment or deviation
- injury from rod handling in raiseborer chamber and/or rod storage location
- injury during management of cuttings at top of the pilot hole
- releases of energy while flushing hole

- catastrophic rod string failure
- rockfalls or bedding separation (particularly coal mines) on breakthrough
- damage to installed services at breakthrough location
- significant inflow of groundwater and/or drilling fluids on breakthrough
- interception of methane gas in coal mines or in metalliferous mines

Main risk considerations

- before the pilot hole is collared, and during the drilling of the first two stabilisers, the dip angle and bearing of the hole should be checked by a competent surveyor
- provide well designed cuttings collection and disposal facilities to minimise the risks of bogging the rod string and injury from manual handling
- provide adequate protection to persons from flying debris during hole flushing
- minimise the risk of rod string failure by use of crack detection procedures prior to site mobilisation
- ensure deviations in directional drilling fall within agreed limits and rates of change
- limit excessive hole deviations while directionally drilling to reduce raisebore rod stresses during reaming
- ensure a managed and effective rod rotation system between projects
- ensure operating procedures include timely and effective barricading of the breakthrough position to prevent injury from rockfalls on breakthrough
- in coal mines assess the risk of poor roof conditions in the proximity of the breakthrough position. Bedding separation may be caused by ingress of groundwater from the hole or release of accumulated gas
- ensure a ground water control plan is in place prior to breakthrough
- ensure that any installed services adjacent to, or at, the planned breakthrough position are either removed or effectively isolated

Reaming and Cuttings Removal

Required outcomes

Reaming and cuttings removal operations which do not expose personnel to high-risk situations.

Main risks

- crush injury or manual handling injury during reamer assembly and attachment to drill string
- dust contamination of mine ventilating air during reaming
- water or 'mud' (cuttings) inrush
- 'hang up' and subsequent sudden failure of dry cuttings
- brow failure while personnel are working in the vicinity of, or adjacent to, the brow
- interception of methane gas in coal mines or in metalliferous mines
- exposure to injury from falling rocks or debris while inspecting or changing raiseborer head cutters at the bottom of a partially reamed hole
- catastrophic drill rod or reamer stem failure resulting in rods and/or head falling to the bottom of the hole or becoming jammed in the hole in an inaccessible location
- cuttings are removed from the active raisebored hole and dumped and/or stored in unsafe situations

Main risk considerations

- develop Safe Work Procedures for cuttings removal from formal hazard identification and effective control of risks *(ref MDG 1010)*
- implement appropriate Safe Work Procedures or utilise Job Safety Analysis *(Ref. Safety Management Plan Workbook)*
- provide effective dust suppression
- include control of hazards associated with build up of dry cuttings in the raisebored hole in Safe Work Procedures for cuttings removal
- conduct a risk assessment of planned short and long term storage or dumping locations for raiseborer cuttings. Use of vertical storage and shaft hoisting to be considered as potential major hazards
- particular attention to be given to geological and geotechnical assessment of ground conditions at and adjacent to the planned breakthrough position of the pilot hole. Install ground support to meet both short and long term requirements
- develop and implement Safe Work Procedures, based on formal risk assessments, which control the risks associated with inspecting or changing reamer cutters at the bottom of a partially reamed hole
- consider the use of a physical shield in conjunction with an inflatable balloon to provide protection against falling rocks when inspecting cutters

- implement procedures which control any potential ingress of methane gas in coal mines
- minimise risk of rod or reamer stem failure by addressing the factors which may contribute to a failure *(ref Technical Reference Material – MDG 1030TR)*
- should a rod string or reamer stem fail, implement controls which minimise or eliminate exposure to risks from falling rocks in the raisebored hole during reamer / rod recovery.
- slinging and rigging work to be carried out only by competent persons
- sudden airflow into a coal mine on reamer breakthrough to surface should be simulated and appropriate controls and procedures implemented to provide site security and to minimise the risk of contraband entering the mine
- develop and implement 'open hole' fall protection controls and procedures.

Demobilisation

Required outcomes

Leaving a secure site after safe removal of the reamer and all associated equipment and infrastructure from a completed raisebored hole.

Main risks

- equipment or material falling down a completed hole
- exposure to falling objects during reamer removal while working at or adjacent to the bottom of a completed hole
- provision of personnel protection devices and/or equipment that does not meet industry design standards
- hazards associated with slinging, rigging and foundation stability during reamer removal at the top of a hole
- in coal mines the potential for contraband or flame to enter gaseous atmospheres on reamer breakthrough to surface
- personnel falling into an open hole.

Main risk considerations

- prior to breakthrough identify potential hazards, conduct a risk assessment, and implement controls and procedures which minimise the risk of equipment or material falling down the hole
- if working adjacent to the bottom of a completed hole consider the use of a physical barrier which is designed and manufactured to withstand any known potential impact
- if removing a reamer at the bottom of the hole, consider the use of remote reamer breakout equipment or the use of long lances to remove the reamer. This may be particularly applicable when the hole has become unstable and the risk of rock falls from within the hole is high
- the reaming of the final section of the hole should be designed and carried out to minimise the risk of failure of the foundations or rock cap

Feedback sheet

Your comment on this Guideline for Raiseboring Operations will be very helpful in reviewing and improving the document.

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

Regional Inspector of Mines - Orange
Mine Safety Operations
NSW Department of Primary Industries
Locked Bag 21
Orange NSW 2800
Australia
Fax: 61-2-6360 5363

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

What do you find most useful about the Guideline?

What do you find least useful?

Do you have any suggested changes to the Guideline?

Thank you for completing and returning this Feedback Sheet

Appendix

DEPARTMENT OF MINERAL RESOURCES – MINE SAFETY AND ENVIRONMENT DIVISION

LEGISLATION UPDATE

No. 2/2001 **27 November 2001**

RANGE OF OHS SUPPORTING MATERIAL WITH LEGAL STATUS

Occupational health and safety (OHS) laws aim to promote and secure the health and safety of persons at work.

As well as having strict requirements under Acts and Regulations, the legal framework has developed in a way that recognises the need for some flexibility for industry to address individual circumstances.

Over time, a range of supporting material has been developed. This material takes the form of codes, standards or guidelines, which may collectively be called OHS supporting material.

Although it is not strictly speaking the law, this material usually has some legal status. This status will vary with the nature of the material and its relationship to the law.

The following table summarises the range of instruments which may influence OHS from a legal perspective. This includes not only Acts and regulations themselves but also examples of the supporting material.

The content of this Table is intended for general guidance only and should not be relied upon as a source of legal advice.

INSTRUMENT	GENERAL PURPOSE	APPLICATION	LEGAL STATUS
Act of Parliament	Creates powers, authorities, duties or rights (including power to make regulations)	Binding – requirements must be complied with (unless a valid exemption is held).	Acts are statutory law.
Regulation made under an Act	To give expression to an Act – to say what is to be done or achieved.	Binding – requirements must be complied with (unless a valid exemption is held).	Regulations are subordinate legislation.
Condition of Exemption or Approval	To allow imposition of conditions.	Binding – requirements must be complied with.	Delegated administrative law .
Standard (AS ISO IEC)	To define accepted practice or minimum standard.	Depends on relationship with regulation – may be binding (if called up by regulation) or persuasive (by existence of the Standard itself).	Depends on relationship with regulation – may be binding (if called up by regulation) or informative (by existence of the standard itself).
Approved Industry Code of Practice under the Occupational Health and Safety Act	To provide practical guidance on how to meet general OHS requirements.	Persuasive – indicates what to do but does not mean it has to be done. Alternative measures may be used.	Admissible in support of allegation that general duty of care has been breached.
Applied Code, Standard or Guideline [1]	To provide practical guidance on how to do or achieve requirements of regulations.	Persuasive – indicates what to do but does not mean it has to be done. Alternative measures may be used.	Most likely admissible in support of allegation that general duty of care has been breached.
Published Guideline	To provide guidance on how to assess and manage a particular risk or set of risks.	Advisory – provides advice on how to manage the relevant risk(s).	May be admissible in support of allegation that general duty of care has been breached.
Guidance Note	To provide background information that may be used in developing risk controls.	Informative	Could be admissible in support of allegation that general duty of care has been breached.
Technical Reference Document	To convey technical information.	Informative	May support expert evidence.
Safety Alert	To make industry aware that something has happened.	Informative	May provide evidence of the 'forseeability' of risk of injury.

[1] Under clause 14 of the Coal Mines (General) Regulation 1999.

TECHNICAL REFERENCE MATERIAL

FOR

RAISEBORING OPERATIONS

MDG 1030 TR

Prepared for:	Chief Inspector NSW Department of Primary Industries
Date completed:	June 2003

PREFACE

The contents of this report may be used as fundamental input into any risk assessment process associated with the planning, design, contract development, site establishment and completion of a raiseboring project. As such, a copy should be provided to each member of a risk assessment team to assist in developing safety and health controls that are tailored to a mine's particular circumstances.

The material covers the major elements of a raiseboring project as identified by a New South Wales industry working group.

The process of raiseboring from the design and planning stage to site demobilisation is depicted by a flowchart in MDG 1030 – *Guideline For Raiseboring Operations.*

The raiseboring process consists of:

1. **Planning & Design –** consideration of relevant information to enable timely and effective project planning and design, which includes controls of identified hazards.

2. **Contract Development –** establishing an agreed contract scope that identifies and includes major hazards and controls which may form part of the tender evaluation process.

3. **Site Establishment & Mobilisation –** considerations during the mining, equipping and provision of services for the total raiseboring operation.

4. **Pilot Hole Drilling –** establishing the pilot hole to planned specifications to enable reamer attachment.

5. **Reaming and Cuttings Removal –** reaming the raisebored hole to final design diameter, and the safe disposal of cuttings.

6. **Demobilisation –** considerations during the removal of services and equipment from the project site.

It is particularly important that risk assessments and the development of hazard controls include a review of all elements of the project as identified by MDG 1030 and the additional material and references contained in this Technical Reference.

The principle objectives of this document are to provide:

- examples of good industry practice;
- issues that should be considered in developing safe systems of work for raiseboring operations; and
- identification of various technical and management solutions.

Issues to be considered with each of the raiseboring project elements are identified and guidance material is provided from page 6 onwards in this document – 'Guidance Material for Raiseboring Operations'

WORKING GROUP MEMBERS

The NSW Chief Inspector of Mines set up a working group to develop this guidance material. Their contribution is appreciated and acknowledged with thanks.

The working group members were:

Mr Brett Amos	Area Manager Mechanised Boring – Australia, Baker Hughes
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Mr Scott Jones	Manager Mining, Ridgeway Gold Mine, Orange, NSW
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GUIDANCE MATERIAL FOR RAISEBORING OPERATIONS

ACTIVITY ELEMENTS OF RAISEBORING

Element: PLANNING and DESIGN

The planning and design of a raisebore hole should incorporate consideration of hole location, length, inclination and diameter, ground conditions, water and gas occurrences, ventilation and drillability. The objective is to achieve a stable excavation that meets the design purpose for the duration of its planned life. The scheduling of the project should also take into consideration these factors to ensure that activity sequencing and timing does not compromise safety.

Activity	Issues to be considered	Notes and Possible Controls
Scheduling	Delayed design and inaccurate scheduling may result in compromising the design resulting in angled holes, when vertical hole design may otherwise have been possible. Angled holes increase stress on drill string and increase the risks associated with reamer collaring and head removal.	Early identification of the need for raisebored holes in medium term mine planning schedules. These should incorporate all access and associated development for the project. Integrate hole design with general mine development scheduling to avoid modifications having to be made from a vertical hole to an inclined hole design due to lack of time. Schedules should be based on realistic development rates which take into consideration hole location, geological and geotechnical conditions, ventilation, groundwater, gas occurrences etc
Scheduling	Metalliferous Mines - unplanned significant changes to ventilation airflow.	Ventilation modelling and simulation during the design phase should ensure that vent control devices are ready and in place prior to breakthrough. Prior to breakthrough, procedures should be in place and communication with supervisors and all crews established. Suggested controls are: ▪ Prior planning and ventilation simulation. ▪ Breakthrough procedures to include anticipated ventilation changes.
Scheduling	Geotechnical assessment and availability of results are made available too late to be incorporated into potential design changes. This may lead to reduced confidence in information by a contractor when preparing the tender bid.	Allow sufficient time for completing geotechnical evaluations within the project plan. Should the evaluation of information from geotechnical drilling and /or mapping be included in the project design, then allow adequate time for the design to be modified if necessary, and for quality information to be made available to tenderers. This will increase confidence in assessments of ground conditions. This could then prevent last minute changes and inadequate preparation that could place the project at a higher risk level.

Activity	Issues to be considered	Notes and Possible Controls
Design	Ventilation design considerations Coal Mines – risk of major changes to ventilation circuits and the potential for methane emissions during pilot hole drilling and reaming. A particular risk may exist at the completion of reaming. Methane may be generated from coal seams, coal strata and possibly porous sandstone.	Consideration should be given in the design phase of the project to the provision of controls for changes in the mine ventilation system and potential methane emissions during and after the raiseboring operation. The majority of shafts drilled in coal mines are usually intended to be used as future exhaust ventilation shafts and are therefore located in the return airway. Consequently, any dust and gas that may be generated while reaming is drawn out of the mine via the return airways. This also means that the shaft and pilot hole will be downcasting past the drill pipe while reaming. Upon breakthrough at the completion of reaming, short-circuiting of the mine's return airway system could occur. Therefore, prior to breakthrough, a ventilation plan must be prepared and be ready to be put in place. This may consist of additional brattices, overpasses and vent walls, much of which can be constructed prior to breakthrough. However, this construction must be planned, scheduled and undertaken so that free access to the bottom of the shaft is maintained for mucking and stowage of cuttings and to ensure that an adequate ventilation flow past the bottom of the shaft remains. Access for inspection must also remain. Possible controls to avoid disruption to mine operations due to a changed ventilation circuit on reamer breakthrough are: • Prepare plans and erect ventilation infrastructure prior to breakthrough. • Consider access to the shaft bottom and stowage areas while reaming. There is a potential for methane to accumulate at the cutter head. The hazards of this can be mitigated somewhat by considering the following: • Drilling of the pilot hole will allow drainage of methane from the local strata. Any such methane can then be monitored at the hole collar and the potential for gas accumulation during reaming can be assessed. • While reaming, the mine ventilation pressure difference could ensure a small but significant airflow down past the rods in the pilot hole, resulting in movement of air out of the shaft and into the mine return airways. • This, combined with the air turbulence created by the cutting action of the head and the falling cuttings, should mean that any gas generated at the face will be quickly dispersed into the surrounding air and drawn down the shaft. • This airflow can then be monitored for the presence of methane. • If methane is detected or the hazard is judged to warrant it, a sample of the air at the cutter head can be drawn up through the centre of the drill pipes. • In the event of gas accumulation occurring, then compressed air should be forced down through the drill pipe to flush any accumulated methane from the shaft. • Given the above, possible controls for dealing with methane accumulation are:

Activity	Issues to be considered	Notes and Possible Controls
	In coal mines, ignition of methane or coal dust through frictional energy from cutter head picks and energy induced into and retained by silica particles within the rock mass.	▪ Gas monitoring of pilot hole to assess the potential hazard. ▪ Maintain shaft through ventilation, with as strong a ventilation pressure difference as possible. ▪ Regular gas monitoring at top and bottom during reaming. In the event of hazardous levels of gas being detected, then consider: • Ceasing reaming and flushing the pilot hole with compressed air through the drill pipe and water down the outside of the pipe. • Sampling gas accumulation at the head through the drill pipes. Control measures for frictional ignition of methane or coal dust may relate to pick design, water flushing and head rotational speed (aimed at limiting input energies to the rock mass)
Design	Geological / geotechnical assessment. Inadequate geological and geotechnical evaluation creating an increase in the risk of falling ground and/or caving during reaming, during cutter inspections, during head removal or during post raiseboring activities.	Raiseboring operations require accurate and informed knowledge of the conditions of the rock mass and properties of the rock before a hole is raisebored. Loss of core from diamond drilling of a pilot hole may result in incorrect interpretation of ground conditions. Drill core quality and recovery can be enhanced by: ▪ Appointment of competent drilling contractors and operators. ▪ Use of triple tube coring in overburden and immediately wrapping core. ▪ Paying particular attention to correct handling and orientation of core. ▪ Conducting rigorous and frequent checks on the core barrel, wire line attachments etc. Ground conditions can be assessed during diamond drilling. Rock properties and structural features can be determined from a diamond drill core. The ground conditions must be suitable for a freestanding unsupported excavation. The most important factors affecting stability are: ▪ structural features (folds, faults, foliation, bedding, discontinuities etc), ▪ mechanical properties of the discontinuities and of the rock fabric (tensile, compressive and shear strength), ▪ stress (in situ and mining induced) and ▪ ground water. The risk attached to any raisebore project will depend on the confidence that can be placed in the relevant parameters used to determine assessment results.

Activity	Issues to be considered	Notes and Possible Controls
Design	Rock Quality Inadequate evaluation of rock quality resulting in unplanned penetration rates, excessive cutter wear or rockfalls. In soft rock, some materials such as mudstone change their chemistry when exposed to atmosphere and/or water.	Penetration rates are a function of rock mechanical properties, namely: strength, abrasivity and hardness. Strength can be tested and described as tensile (direct method or Brazilian testing), shear (shear box testing) or compressive (uniaxial or point load testing). Abrasivity can be tested in Los Angeles Machine and hardness can be described as raiseboring index or hardness index. Quartz content in the rock fabric may give an indication on rate of cutter wear. The physical structure of such materials may change and become 'putty like' or disintegrate altogether. This change is usually time dependent.
Design	Stability Index Inadequate evaluation and /or use of inappropriate or inaccurate stability index. The potential for the intersection of zones of 'running sands' in sandstone.	There are a number of rock mass classification systems that are available to combine geotechnical parameters and excavation stability. For raiseboring purposes the most commonly used is the "Q" system modified by McCracken and Stayce. This system takes into account rock block size (Rock Quality Designation and joint set number), discontinuity shear strength (joint roughness and joint alteration) and active stress (Water Reduction Factor and Stress Reduction Factor). For a raiseboring purpose, the system has been modified by introducing adjustments for orientation of discontinuities, weathering and wall factor. A raisebore stability ratio is dependent on the function of the hole and on its planned life. The stability ratio of 1.3 is usually assigned for ventilation raises and 1.6 for ore passes. If not detected during exploration drilling and effectively managed, uncontrolled inrush of water and sand could occur. Hole collapse is likely under these conditions. Control measures can include hole lining or freezing of ground. The potential for running sand should be detected during exploration drilling. However, this may prove difficult if the density of drilling mud is greater than the liquefied sand.
Design	Determination and management of water occurrence and flows. Inadequate evaluation resulting in unplanned water ingress.	Analyse major structures in the planned path of raise that may be water bearing. Raiseboring generally precludes the immediate provision of sealing ground where water bearing strata is intersected. Analyse data from filled/unfilled stopes adjacent to path of raise – is the fill wet, dry, saturated and / or stabilised. Measures should be taken to ensure circulation is maintained when a pilot hole is drilled through a filled stope or development void. During drilling a geotechnical drill hole and a pilot hole, ground water conditions should be closely observed and monitored. Should water be expected or encountered, pump tests should be carried out to determine permeability and the rate of water inflow. Rock samples should be tested for permeability. Continuous monitoring of water inflow to the underground excavations should be carried out. Results from water testing, permeability tests and changes in water inflow should form a basis for analysis of risk and quantity of water inflow during raiseboring.

Activity	Issues to be considered	Notes and Possible Controls
		Consider an extended pre-sink if there is unconsolidated water bearing material near the collar of the raise If a wet hole is anticipated, the mine design should include provision for water be directed and controlled at the bottom of the raisebored hole. Consideration should be given to the provision of adequate water storage to protect major infrastructure like pumps and electrical installations. Adequate standby pumping capacity should be provided. Consider pressure grouting.
Design	Major Structures. Inadequate evaluation, resulting in potential rockfalls.	The major factor affecting the stability of a raisebored hole is its diameter. The face stability can be determined in terms of maximum unsupported span that is a function of the raise bore stability index. During reaming the face is more liable to instability than the sidewall, although during the cutting operation itself the raiseborer head provides a degree of support. The potential for failure wedges should be analyzed in terms of the potential for key block failure, i.e. failure of a particular block that would produce a domino effect and subsequent gravity failures, causing significant damage to the raise wall. Different stability criteria may be considered acceptable for the raise face and raise walls. The raise face is temporary and its failure is likely to affect the raisebore head. The raise walls are permanent and their failure may lead to progressive and catastrophic failure after completion of raiseboring operations. Failure may be caused by gravity falls or slides of joint determined blocks or wedges, or by displacement by the cutters.
Design	Drillability. Avoid cutter changes by selection based on drillability. Inadequate evaluation resulting in the need for unscheduled cutter inspections / changes.	Whenever the head is lowered for cutter inspections or changes, the support at the face is withdrawn. It is at this time that failures are most likely. Failures from the edge of the face can subsequently undercut the sidewall. An uneven face can create vibrations when re-establishing reaming at the face.
Design	Raiseborer Chamber. Inadequate support design results in ground instability.	Changes in mining induced stress or long stand up time can result in loosening of rock in the backs or walls of the chamber. Raiseboring chambers are often characterized by a high height to width ratio. With such a ratio it may be difficult to notice any changes in geotechnical conditions. It is also difficult to install ground support once the raiseborer and ancillary equipment is installed. It is recommended that, as a minimum standard, all raisebore chambers are fully supported with standard bolts and meshed. In poor or fair ground conditions a competent person should specifically design ground support for each chamber.

Element: CONTRACT DEVELOPMENT

A raiseborer project contract should be accurately scoped, and include systems that have identified and risk-ranked potential hazards with appropriate actions to control them. A contract should be fully scoped and completed prior to project commencement. The contract should then be written so that safety systems contained within it can be audited throughout the contract term. A contract should minimise the likelihood of 'surprises' that may adversely affect the project's safety performance.

Activity	Issues to be considered	Notes and Possible Controls
Contract Development	The design specifications for the hole and associated development may not have been completed prior to contract tendering. This may reduce the level of confidence for tendering accurately.	There is a risk that the principal and / or the contractor may possibly revert to risk taking to recover contract shortfalls The principal could provide background and a statement of confidence as supporting information in tender invitations. This may enable tenderers to minimize the use of 'contingencies' to provide protection against potential shortfalls.
Contract Development	Quality & scope of geotechnical information.	The principal should provide all relevant geotechnical information to tenderers. Also, the principal should be prepared to demonstrate consideration of the geotechnical risk considerations listed in MDG 1030 as well as any other site-specific hazards.
Contract Development	Safety Management Plan / Contractor's Safety Management Plan.	Ensure that appropriate review and 'sign off' as part of the relevant Safety Management Plan (SMP) meet legislative requirements *(e.g. in NSW ref Mines Inspection Act 1901 General Rule 2000 Clause 11)* In particular, consideration should be given to provide documentation in a contract to support the following programs: - ▪ Policy ▪ Document Control ▪ Hazard Identification ▪ Risk Assessment ▪ Emergency Response Planning ▪ Consultation & Communication ▪ Job Safety Analysis ▪ Safe Work Procedures ▪ Hazard Reporting ▪ Fitness for Work ▪ Equipment Maintenance ▪ Injury / Illness Reporting ▪ Accident Investigation ▪ Environmental Monitoring ▪ Health Surveillance

Activity	**Issues to be considered**	**Notes and Possible Controls**
		▪ Personal Protective Equipment ▪ Contractor Management ▪ Training & Competency Assessment ▪ Audit & Program Review
Contract Development	Tender Prequalification.	Consider a prequalification process based on an evaluation of the proposed Safety Management Plan for the project. Each program can be evaluated and 'scored' to rank each tender. Eliminate tenders that do not meet a predetermined minimum standard which could provide the principal and contractor with auditable safety systems throughout the duration of the project. This prequalification process should not include evaluation of contractors' commercial submission. Evaluation of commercial tenders should only be initiated once contractors have successfully completed the prequalification stage. Consideration should be given to ensuring all relevant risks are identified, and that they are adequately addressed in the successful tender. Reference should be made to hazards included in MDG 1030 – *Guideline for Raiseboring Operations*, and MDG 1015 - *Guideline for Mobile and Transportable Equipment for Use in Mines*. If not addressed in the tender, ongoing negotiations are recommended to ensure an agreed and documented Safety Management Plan is in place. The Plan should include provision for all required safe work procedures to be available prior to project commencement. Relevant sections from the principal's Mine Safety Management Plan should be made available to tenderers at this stage. Then opportunities should be provided for tenderers to seek clarification and input.
Contract Development	Tender Evaluation. Inadequate assessment of a tenderer's commitment to safe systems of work. Safety Management Plan audits.	A tender evaluation based on price alone is unlikely to result in a commitment to safety from either the principal or the contractor. Consideration should be given to adopting a tender evaluation process that includes all the relevant criteria that may affect the safety performance and success of the project. A weighted and scored criteria decision making process may be deemed suitable. *(for example, ref Kepner Tregoe decision making process)* The tender evaluation and contract negotiation processes provide the best opportunity to ensure that effective safety systems are planned, documented and meet the relevant legislative requirements. The agreed contract document can then be used to audit the safety system throughout the project. A systematic approach at the tender evaluation and contract development stages may provide an outcome that results in opportunities for additional and ongoing efficiencies. Implementing a systematic approach to identifying hazards and implementing controls often achieve this.

Element: SITE ESTABLISHMENT AND MOBILISATION

Activities associated with the site establishment and mobilisation of a raiseborer project should be systematically reviewed to minimise risk. The necessary site works and infrastructure should be provided so as not to increase the risk of injury to personnel. When correctly planned and implemented, the outcome can result in a more effective and efficient project.

Activity	Issues to be considered	Notes and Possible Controls
Site Establishment and Mobilisation	Project commencement is delayed because some equipment is not on site. Project commencement is delayed because some equipment is worn or not fit-for-purpose.	The management of the project should include detailed packing lists and checking mechanisms prior to dispatch of equipment from the previous site or storage facility. Prior to site mobilisation, conduct inspections of equipment for tool tolerances, signs of wear etc and replace or repair substandard items. The top wrench should be considered a high-risk component.
Site Establishment and Mobilisation	The construction of foundations and any other 'civil' works required for the raiseborer must be designed to withstand the worst-case scenarios that may arise during the project.	In designing the foundations or raiseborer 'pad' consideration should be given to: - ▪ A design that meets civil engineering principles and standards. ▪ Reaming against caving ground, in blocky ground or through geological discontinuities. ▪ Jammed rods or jammed reamer hole. ▪ Removal of the reamer at the top of the hole on completion.
Site Establishment and Mobilisation	Contamination of surface or underground environment from spillage / runoff of drilling mud, oils or contaminated water.	Ensure the design and installation of sumps, settling ponds and pumping systems are adequate, and effective maintenance programmes are planned.
Site Establishment and Mobilisation	Establish services on time to meet design specifications and project milestones. Services may include: ▪ Compressed Air ▪ Water ▪ Electricity ▪ Ventilation ▪ Communications ▪ Sumps / Pumps	Adequate planning for the provision of services should be made. The project activity schedule should clearly identify when and where services should be installed. A risk assessment should include failure to provide any of the listed services. Adequate control measures may be put in place or planned for. Electrical installations should meet appropriate standards. *(e.g. In NSW ref Mines Inspection Act 1901General Rule Clause 68(1))* Particular consideration should be given to the provision of effective communications between the bottom of the hole and the raiseborer. A planned response should be determined if failure of the communications system occurs at critical times. This should be included in the Safety Management Plan.

<table>
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<tr><td>Site Establishment and Mobilisation</td><td>The transportation of the raiseborer and associated equipment may involve significant hazards.

These include:
Dimensions and weight of components exceed bridge & access limitations
Unplanned movement of equipment
Blocked egress
Failure of slinging and rigging equipment
Failure or damage of high pressure hydraulic hoses & fittings
Injury through poor manual handling practices
Hazards associated with impact by moving equipment and gear</td><td>Consideration should be given to the transportation of the raiseborer and associated equipment to the site(s) being carried out in a planned and systematic way. Hazards should be identified and control measures planned prior to work commencing. Consideration should be given to:
Ensuring equipment weights and dimensions are within limitations (bridges, power lines, road conditions)
Utilizing an escort vehicle / person during transportation.
Taking measures to ensure any noise limitations are not exceeded. Erection of sound barriers at the raiseborer site and the use of rubber buffers when handling and stacking rods may be appropriate.
For sites on surface, consultation with the community and near neighbours should be considered.
Ensure the site is secured to prevent unauthorized entry of persons or wildlife.
The order and timing in which equipment is delivered to the site may result in additional hazards caused by rehandling or inappropriate storage or confinement of the work area.
In order to assess the hazards associated with this phase of the project, the Principal should ensure that the contract scope clearly describes the means of transporting equipment to the raiseborer site(s). Tenderers should have a good understanding of the hazards involved prior to submitting a tender.
Ensure that rod-handling clamps are regularly inspected for wear and are fully maintained to minimize the risk of dropping rods.

Safe Work Procedures and planned controls for this work should be developed after completing a risk assessment. (ref MDG 1010) All identified hazards, Safe Work Procedures and controls should be developed and communicated prior to work commencing.</td></tr>
<tr><td>Site Establishment and Mobilisation</td><td>Adverse weather conditions for surface raiseborer sites.</td><td>Controls may be required to address the hazards associated with adverse weather conditions. The Environmental Monitoring program of the Mine’s or Contractor’s Safety Management Plan should specify procedures to minimize such risks.</td></tr>
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Element: PILOT HOLE DRILLING

A pilot hole should break through on schedule and to the planned location without damage to any installed services. There should be no increased risk to persons from falls of ground at, or adjacent to, the break through position.

Activity	Issues to be considered	Notes and Possible Controls
Pilot Hole Drilling	Multiple or severe corrections when directional drilling of the pilot hole (or diamond drilled geotechnical hole) may result in adverse stresses on the drill string during the reaming operation. Enlarging a directionally drilled hole.	Consideration should be given to determining acceptable deviation tolerances in the pilot hole drilling prior to commencement of the hole. These tolerances should be stated in the contract documentation. Also, planned corrective actions should be established when certain triggers occur. These trigger levels and predetermined actions should be documented and supported by justifications through relevant data and calculations. Consideration should be given to the type of drill used to increase the diameter of a directionally drilled hole to full pilot hole size. Should a hammer rig is used with conventional rods, the stiffer raiseborer rods may jam in the hole.
Pilot Hole Drilling	Missing the planned target – particularly when directional drilling is not utilized. Locating a pilot hole that has missed a target.	A competent surveyor should rigorously check the setting up and alignment of the raiseborer. This should be carried out both prior to, and immediately after, collaring of the pilot hole and before drilling continues. Particular circumstances that would which initiate realignment of the raiseborer, should be decided and included in the contract scope. Consider incorporating contingency plans in the project scope should a target be missed. Methods employed to locate a pilot hole that has missed a target depend on the following variables: ▪ Length of the hole – longer the hole the lower the level of confidence in predicting actual location ▪ Location, frequency and orientation of geotechnical features intersected by the pilot hole ▪ Availability and location of adjacent development and development on intermediate levels ▪ Occurrence and flow rates of groundwater intersected by the pilot hole ▪ Quality of groundwater – possibly acidic, radioactive or unusually hot Consideration may be given to utilizing the following methods when locating pilot holes: ▪ Locating the hole using gyro, radio, sonar, sonic, camera survey or other technique. ▪ Developing an access drive from intermediate level development to intersect the hole. This will then facilitate survey pick up and recalculation of the hole coordinates at the breakthrough elevation.

Activity	Issues to be considered	Notes and Possible Controls
	Locating a pilot hole that contains water.	If the pilot hole has the potential to contain water then controls should be established to minimize the risk of water inrush on breakthrough. These controls may include: ▪ Drilling diamond drill holes to intersect the pilot hole through securely bolted standpipes that are fitted with appropriately pressure rated gate valves. ▪ Filling the pilot hole with rock aggregate and mining towards the best-estimated position. ▪ Developing towards the best-estimated position using remote drilling techniques. This should incorporate sidewall water-cover drilling. A Job Safety Analysis should be carried out and a Safe Work Procedure developed, documented and communicated.
Pilot Hole Drilling	At the top of the pilot hole, hazards associated with sudden releases of energy while flushing the hole may 'throw' cuttings at high velocity significant distances from the collar.	Attempt to eliminate this risk by engineering the collar configuration such that cuttings are kept clear of the hole. Frequent flushing can also reduce the extent of build up of cuttings in the hole. Utilize a correctly engineered and installed Blooie system. *(ref Atlas Copco Robbins Raise Boring Handbook)* If manual removal of the cuttings is required, complete a Job Safety Analysis for the task to identify controls to minimize the risks.
Pilot Hole Drilling	Potential injury during rod-handling.	Consider the use of a Job Safety Analysis to review rod-handling operation to develop appropriate controls and procedures. Each project may introduce unique hazards due to the development configurations and equipment used.
Pilot Hole Drilling	Rod rotation / sequencing	Sequencing of the use of rods should be incorporated as part of the operation to minimize rod failure through repetitive exposure to high torque or high stress events. Establish an effective rod identification and management system to minimize errors. Such management systems could include a computer database of rod history and condition monitoring as well as auditing of on-site compliance to this system.
Pilot Hole Drilling	The planned pilot hole breakthrough position may contain reticulated mine services (air, water, electric cables, ventilation ducting) which could be damaged on breakthrough.	Consider the potential consequences of failing to remove or isolate services prior to breakthrough. Significant safety hazards and disruption to the mine operations may result. The contract scope should include the identification of installed services and information on isolation procedures.
Pilot Hole Drilling	Potential rockfalls / ground movement at, and adjacent to, the pilot hole breakthrough position. Implement controls prior to breakthrough of the pilot hole.	The area surrounding the breakthrough position should be check scaled and, if necessary, additional ground support installed, prior to any person approaching the breakout position or attempting to breakout the pilot bit. At breakthrough there may be some localized falls of ground accompanied by a wash of drilling fluid. It is important therefore, that the immediate area be barricaded and cleared of persons and that all persons working in the area are aware of an imminent breakthrough. Controls which may be considered before breakthrough occurs include:- ▪ Initial planning to take into account roof conditions and other geotechnical considerations. ▪ Prior to commencing pilot hole drilling, the breakthrough position and planned drilling depth should be determined by a competent design engineer and/or surveyor.

Activity	Issues to be considered	Notes and Possible Controls
	Inspection of the breakthrough position.	▪ Any additional ground support as determined should be installed. ▪ The area should be barricaded off and appropriate signage installed. ▪ Procedures should be implemented to ensure sufficient warning is given to persons working in the vicinity of the breakthrough. ▪ The weight on the drill bit should be reduced as breakthrough is approached. ▪ A water management plan is in place Following breakthrough of the pilot hole, the raiseborer should be shut down and isolated and the breakthrough position inspected. The inspection should focus on localized back (roof) or wall (rib) failure and, in coal mines, for methane or other gasses emerging from the hole.
Pilot Hole Drilling	On breakthrough significant water flows may enter the breakthrough location.	Using estimates of water inflow obtained during the planning / design stage of the project, an adequate and effective water management plan should be established prior to pilot hole breakthrough. Consider the potential effect of additional water flows on the mine drainage and pumping system. Also, the design and operation of sumps should be reviewed to manage excess water from raiseborer cuttings during removal and disposal.
Pilot Hole Drilling	It may be necessary to re-collar the pilot hole bit in the floor of intervening development.	The optimum design for a raisebored hole sometimes involves the intersection of intervening development and the re-collaring of the pilot hole in the floor. This is particularly common in raisebored slot raises in large multi-level open stopes in metalliferous mines. The controls for pilot hole breakthrough described above should be repeated on each occasion intervening development is intersected. Additional hazards may be identified in this configuration. These include control of drill cuttings and drilling mud after re-collaring, isolation of personnel from rotating drill rods in a remote location and control of groundwater from the completed section of the pilot hole. A Safe Work Procedure should be specifically developed for this operation.
Pilot Hole Drilling	Preparation of the reaming chamber (bottom of the hole).	The design of the reaming chamber should provide adequate space to safely accommodate all planned activities in the area. Planned activities should take into account contingencies for cutter inspection or replacement and head recovery operations if a drill string fails and rods and/or a reamer fall to the bottom of the hole. Additional ground support should be considered before the reamer is in position to support the edge of the newly cut hole. Should the pilot hole miss the design breakthrough position, consideration should be given to additional mining and ground support to ensure reamer attachment and detachment operations are not compromised.
Pilot Hole Drilling	Review the pilot hole drilling records.	Review the pilot hole drilling records to identify additional hazards that affect the reaming phase. Develop controls to minimize risks.

Element: REAMING AND CUTTINGS REMOVAL

Reaming and cuttings removal activities should be planned and managed systematically so as not to expose personnel to high-risk situations.

Activity	Issues to be considered	Notes and Possible Controls
Reaming and Cuttings Removal	Should the back (roof) at the breakthrough location not be perpendicular to the direction of the hole, the rod string and reamer may be subjected to stresses that could result in catastrophic failure.	Prior to moving the reamer to the breakthrough location survey the rock profile at the collaring position. Should the profile not meet acceptable tolerances, strip the area until the back (roof) is flat and perpendicular to the direction of the hole.
Reaming and Cuttings Removal	The potential for injury and equipment failure during preparation and assembly of the reamer in the reaming chamber.	Consideration should be given to the risks involved during the reamer assembly operation. The risk level can be higher due to the size and weight of components, the need to work in confined spaces, poor ventilation and the priority and urgency of the project. Consideration should be given to using Job Safety Analysis to review every stage of the reamer assembly operation.
Reaming and Cuttings Removal	The following hazardous events have been known to occur during reaming: - ▪ Dust contamination of mine ventilating air ▪ Water inrush ▪ Mud / cuttings inrush ▪ Hang up of dry cuttings ▪ Dropped rods and / or reamer (or parts of) ▪ Brow failure ▪ Ground failure of reamed hole face or sidewall	As part of the site establishment, provision for effective dust suppression / confinement should be made. This may consist of: ▪ Installation of water sprays ▪ Installation of curtains adjacent to the brow ▪ Installation of a ventilation door(s) to isolate the area. ▪ Installation of a dedicated ventilation fan & ducting to directly exhaust to a return airway. Consideration should be given to including control measures for the hazards associated during the removal (bogging) of cuttings from the bottom of the hole. Controls may include: ▪ Documented inspection procedures to assess the quantity of cuttings present and the status of the brow (open / closed / wet / dry / dusty / clear) ▪ Implementing a planned programme of cuttings removal, with appropriate priorities, as an integral part of the mine operations schedule. Include reconciliation of volume reamed v volume bogged ▪ Ensuring regular communication between the raiseborer operator and the person responsible for ensuring that cuttings removal occurs. This communication should include the current rate of reaming and the achieved progress compared to planned advance

Activity	Issues to be considered	Notes and Possible Controls
		▪ Scheduling inspections and / or cuttings removal at predetermined 'hold points' as reaming progresses. The 'hold points' should be calculated such that, providing cuttings are removed to a predetermined level, the brow never becomes closed ▪ Ceasing reaming during inspections and bogging to eliminate the risk of rod / reamer failure while persons are in the proximity of the bottom of the hole. ▪ Ceasing reaming should the brow become closed with cuttings. ▪ Provision of adequate cuttings storage and disposal sites / strategies. ▪ Provision of predrilled drainholes into the brow to intersect water running on the footwall of the raisebored hole ▪ Using a remote or tele-remote loader for cuttings removal ▪ The loss of brow profile may introduce significant additional hazards during cutter inspections or changeouts and during demobilisation. Geotechnical assessments during the planning and mine development stages of the project should focus on ensuring the brow remains intact during reaming. ▪ Considerations should be given to establishing procedures which minimize the risk of injury should there be ground failure. These may include the installation of barricades and ceasing reaming during inspections of the bottom of the hole
Reaming and Cuttings Removal	Catastrophic failure of the drill rods or reamer during reaming. Does the Safety Management Plan include controls and procedures to address the hazards arising from these factors?	Factors which could contribute to catastrophic failure of the reamer or drill rods include:- ▪ Reaming large diameter inclined holes ▪ Excessive hole deviations in a directionally drilled pilot hole ▪ Poor maintenance of raiseborer and ancillary equipment ▪ Poor management of rod sequencing system ▪ Lack of catch rope on a vertical hole ▪ Inadequate training and competence levels of operators ▪ Inadequate establishment and / or implementation of QA procedures for the drill string and the reamer. These include non-destructive testing and rod rotation. ▪ Failure of the reamed hole sidewall or face ▪ Squeezing and distortion of pilot hole through ground movement ▪ Exceeding maximum operating hours for in-the-hole equipment ▪ Using an inappropriate or poorly designed reamer head – particularly in large diameter raises.
Reaming and Cuttings Removal	Cutter inspections and changes during reaming. Cutter condition.	During the planning / design phase of the project, the selection of cutters should include an assessment of estimated wear rates and condition of previously used cutters. Worn cutters should only be used if: ▪ there is a high level of confidence that they will not require replacement before the hole is completed or ▪ replacement before completion of reaming is unavoidable. The use of new cutters may eliminate the hazards involved in lowering a reamer to the bottom of a partially completed hole for an inspection of cutter(s) condition or cutter replacement.

Activity	**Issues to be considered**	**Notes and Possible Controls**
	Risk assessment for cutter inspections / changes.	Should it be necessary to lower the reamer to the bottom of the hole for inspection and / or replacement of cutter(s), a risk assessment of identified hazards should be undertaken *(ref MDG 1010)* and controls established to eliminate or minimize those hazards. Controls may include: ▪ Never allowing personnel to pass beyond the brow or predetermined 'no go zone' under any circumstances ▪ Erection of barricades and signs to prevent access to high risk areas or by unauthorized personnel ▪ Definition of an 'exclusion zone' adjacent to the brow for all personnel ▪ Provision of lighting ▪ Completion of a Job Safety Analysis by all personnel involved in working at or in the vicinity of the reamer
	Use of a physical shield or barrier.	▪ Use of a physical shield or barrier that provides protection to personnel from falling rocks while working adjacent to, or beyond, the brow. Any such barrier must be designed to withstand any potential loading which may be applied to it
	Use of an inflatable balloon	▪ Use of an inflatable balloon positioned in the raisebored hole above the brow. Should a means of access to the raisebored hole be available above the brow elevation, and additional or higher risk hazards are not introduced, consideration may be given to positioning a layer of hay or other suitable protection from sharp impact on top of the balloon A balloon should: - ▪ be used in conjunction with a physical shield or barrier if it is intended for personnel to be in close proximity to the brow ▪ be inflated prior to transport to the worksite and tested for significant leaks and inspected for structural damage and general condition be designed to withstand and absorb the kinetic energy from the maximum potential impact by falling rock(s) ▪ be constructed to an inflated diameter which is within acceptable tolerances of the actual raisebored hole diameter ▪ be transported and installed with fit-for-purpose equipment ▪ be positioned in accordance with safe operating procedures ▪ not be installed until the availability of compressed air to the worksite can be guaranteed ▪ be maintained at a constant design air pressure using an air pressure regulator and a distribution manifold ▪ have adequate top and tail rope lengths to ensure personnel can work outside any exclusion zone ▪ be installed with it's suspension cable passing through a 'low friction surfaced ' pipe inserted into the inclined borehole into the raise. This will allow easier movement of the

Activity	Issues to be considered	Notes and Possible Controls
		suspension cable during insertion into the borehole and reduce the risk of abrasive wear ▪ have all attachments to the balloon, including the inflation hose, completed before the balloon attachment points are positioned within the exclusion zone.
Reaming and Cuttings Removal	Hole completion – rock cap fails due to reaming too far before the reamer is lowered to the bottom of the hole for removal. Not possible to blast rock cap due to unacceptable risks.	The rock cap design depth should take into account geological and geotechnical information. In competent ground a 'rule of thumb' minimum depth of two raise diameters below the machine is often applied. If the failure of the rock cap is assessed to be an unacceptable risk then the pre-collar should be extended and filled with suitably designed concrete. Consider mounting the rig on an extended reinforced concrete raft. Consider provision of designed and tested tie off points to provide anchorage in the event of rig movement or rock cap failure.

Element: DEMOBILISATION

On completion of a raisebored hole, risks should be minimised when removing the reamer and equipment. Areas at the top and bottom of the hole should be left in a safe condition.

Activity	Issues to be considered	Notes and Possible Controls
Demobilisation	Removal of reamer – top of hole	Consideration should be given to establishing controls for the following hazards:- ▪ Personnel falling into an open hole ▪ Head falling to the bottom of the hole due to inadequate attachment or slinging procedures or standards ▪ Foundations failure leading to machine instability and misalignment ▪ Falling materials, rubbish etc down the hole creating hazards at the bottom ▪ In Coal mines the creation of a hazardous zone if flame or contraband enters the underground workings from surface via a raisebored ventilation shaft. Controls may include: - ▪ Installation of an engineered cover or fencing and appropriate signs around the collar of the hole. ▪ Installation of fall protection equipment consistent with 'open hole' Safe Work Procedures. ▪ Prior to the reamer breaking through to surface, clearly designating the surface area adjacent to the collar with appropriate signs. Also, education of personnel as to the meaning and implications of the procedure. ▪ Implementation of rigorous housekeeping standards adjacent to, and at, the worksite. All lifting points, lugs, chains shackles and other lifting equipment and accessories must be designed and installed to withstand the maximum loading with appropriate safety factors The use of a correctly rated crane to lift a reamer from a completed hole must be considered only after conducting a risk assessment to identify all hazards and establish effective controls. Controls may include: ▪ Valid certification of the mechanical condition of the crane ▪ Valid certification of the mechanical condition and weight limitations of all lifting attachments ▪ Valid certification of the crane operator's competency ▪ Valid certification of the rigger and /or dogman's competency ▪ Identification and use of all site specific permits and authorizations ▪ Restricting access of unauthorized personnel to the worksite

Activity	Issues to be considered	Notes and Possible Controls
		▪ Ensuring adequate lighting / visibility In underground situations where access by crane is not possible, consideration may be given to utilizing a front end loader to lift the reamer from the hole. The risk assessment for this operation may include the following controls: ▪ Documented Job Safety Analysis which includes the configuration, specifications and identification of all steps in the process ▪ Valid certification of the mechanical condition and weight limitations of the loader, it's hydraulic system and all lifting attachments ▪ Valid certification of the loader operator's competency ▪ Valid certification of the rigger and /or dogman's competency or other persons deemed competent by the general manager to be responsible for rigging activities ▪ Identification and use of all site specific permits and authorizations ▪ Restricting access of unauthorized personnel to the worksite ▪ Ensuring adequate lighting / visibility
Demobilisation	Removal of reamer (by unscrewing) at the bottom of the hole.	Consideration should be given to breaking out the reamer remotely in order to eliminate the high level of risk when working under an open raisebored hole. Organizations that have developed and used equipment to carry out this task are listed in the reference section of MDG 1030. A decision to remove a reamer at the bottom of a completed hole should be made after comparing removal methods. The option which is both practical and eliminates or minimizes the risk(s) should take preference.
Demobilisation	Removal of reamer (by destructive cutting of a burn out ring) at the bottom of the hole.	Consideration should be given to identifying all potential hazards associated with this process. In addition to those hazards at the workplace, there may be indirect hazards caused by fumes and resultant variations to normal mine ventilation quantities and quality. Controls which may be considered include:- ▪ Clear definition of responsibilities and roles during the work ▪ Fit for purpose and well maintained equipment ▪ A fully operational and tested communication system between the top and bottom of the hole ▪ Provision of, and training in, all necessary personal protective equipment. This may include fall protection, respiratory protection, hot work protective clothing ▪ Provision of additional ventilation capacity ▪ Notification to the mine workforce that burning is to take place ▪ Clearing of work surfaces of obstructions and trip hazards ▪ Issuing of, and compliance with, all appropriate permits. (permit to work, hot work permit, site isolation …) ▪ In coal mines, compliance with the relevant Codes Of Practice or exemptions from statutory

Activity	Issues to be considered	Notes and Possible Controls
		regulations ▪ Establishment of an 'no go' exclusion zone at the bottom of the hole to minimize or eliminate the risk of injury from falling rocks ▪ Provision of a physical barrier to eliminate the risk of injury from falling rocks. Any such barrier must be designed to withstand the loads that may be applied. ▪ Development of techniques and procedures which maximize the length of the lance. During the risk assessment of this procedure consideration should be given to any potential 'pendulum swinging' effect of the drill string once the burn out ring has been cut.
Demobilisation	The transportation of the raiseborer and associated equipment may involve significant hazards. These include: ▪ Dimensions and weight of components exceed bridge & access limitations ▪ Unplanned movement of equipment ▪ Blocked egress ▪ Failure of slinging and rigging ▪ Failure or damage of high pressure hydraulic hoses & fittings ▪ Injury through poor manual handling practices ▪ Hazards associated with impact by moving equipment and gear	Controls for hazards during demobilization are similar to those during the site establishment phase. A review of the site establishment activities should be conducted and the outcomes incorporated into revisions to any Safe Work Procedures that are applicable to this work. Possible controls are: ▪ In order to assess the hazards associated with this phase of the project, the Principal should ensure that the contract scope clearly describes the means of transporting equipment from the raiseborer site(s). Tenderers should have a good understanding of the hazards involved prior to submitting a tender. ▪ Use of fit-for-purpose equipment ▪ Measures to ensure any noise limitations are not exceeded. The use of rubber buffers when handling and stacking rods may be appropriate. ▪ For sites on surface, consultation with the community and near neighbours should be considered Ensuring equipment weights and dimensions are within limitations (bridges, power lines, road conditions) ▪ Utilizing an escort vehicle / person during transportation. ▪ Ensuring the site is secured to prevent unauthorized entry of persons
Demobilisation	The project design and scope should include provision for the securing of the top and bottom areas of the open hole	Methods for securing the area must take into consideration the full life of the hole. Provision may be necessary for future access or inspections. These should be designed once a risk assessment of all identified hazards has been completed and the resultant controls incorporated into the design. For mines near residential areas, the elimination of the risk of children and other members of the community falling down an open hole should be incorporated into the risk assessment