
Guideline for the Use of Remote Controlled Mining Equipment - Underground Metalliferous Mines

MDG 5002

**Produced by Mine Safety
Operations Division,
New South Wales
Department of
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We wish to thank the Metalliferous Industry Safety Advisory Committee for their 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. Use of this document does not relieve the user (or a person on whose behalf it is used) of any obligation or duty that might arise under any legislation (including the Occupational Health & Safety Act 2000, any other Act containing requirements relating to mine safety and any regulations and rules under those Acts) covering the activities to which this document has been or is to be applied.

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FOREWORD

The original MDG 5002 *Guidelines For The Use Of Remote Controlled Mining Equipment* was developed following a review into mine safety commissioned by the then NSW Minister for Mineral Resources, the Hon Bob Martin MP, in November 1996. The original guideline was developed by task Group One and was first published in February 1998.

During 2002, the Remote Control Equipment Advisory Group (RCEAG) was formed, with representatives from underground coal and metalliferous operators, unions, equipment suppliers and the Department of Mineral Resources (DMR) now the NSW Department of Primary Industries (NSW DPI). The scope and purpose of the RCEAG were:

Scope of RCEAG:

Underground coal and metalliferous mine remote controlled mobile machines that can be operated from off the machine and encompass the life cycle of the equipment and mining method.

Purpose of RCEAG

Review standards, systems, legislation and operational requirements of remote control mobile machines/plants for use in underground coal and metalliferous mines with the intention of minimising risk to personnel.

The RCEAG determined that because of changes in technology and the significant amount of experience that had been gained since the issuing of the original MDG 5002 in 1998, the Guideline should be reviewed and updated. A sub-committee of the RCEAG was formed to review the guideline and update it based on experience gained since its first publication.

Due to the state of implementation of remote control equipment in underground coal and underground metalliferous mines and the significantly different equipment, mining systems and terminology, the working group determined that the Guideline should be divided into two separate documents - one for underground coal mines and the other for underground metalliferous mines.

This Guideline covers the use of remote controlled mining equipment in underground metalliferous mines.

MDG 5002 *Guideline for the Use of Remote Controlled Mining Equipment – Underground Metalliferous Mines* was developed by an underground metalliferous mine working group co-ordinated by the RCEAG sub-committee. The working group consisted of representatives from all major underground metalliferous mines in NSW operating remote controlled mining equipment along with equipment suppliers/ maintainers and DPI personnel. Their constructive evaluation and input into the development of this Guideline is gratefully acknowledged.

This is a Published Guideline. Further information on the status of a Published Guideline in the range of OH&S instruments is available through the NSW Department of Mineral Resources – Mine Safety, Legislation Update Number 2/2001 which is appended to this guideline. The range of instruments includes:

- Acts of Parliament
- Regulations made under the Acts
- Conditions of Exemption or Approval (*Coal Mines*)
- Standards (AS, ISO, IEC)
- Approved Industry Codes of Practice (under the OHS Act, Part 4)
- Applied Codes, 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 and systems for the use of remote controlled mining equipment in underground metalliferous mines. Owners and managers should rely upon their own advice, skills and experience in applying safety standards and systems 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 MDG 5002 Guideline for the Use of Remote Controlled Mining Equipment was distributed to industry for consultation and comment through a representative working group, the Metalliferous Safety Advisory Committee and the Remote Control Equipment Advisory Group.

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



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CONTENTS

PURPOSE AND SCOPE	4
GLOSSARY	4
REFERENCES	6
GENERAL	7
Record keeping and documentation	7
Training	7
Monitoring, systems audit and review	8
Risk identification and assessment	8
REMOTE CONTROLLED MINING EQUIPMENT	9
Line of Sight Operations	9
TelereMOTE Operations	11
Planning and Design	12
Safe Work Locations	13
Maintenance	14
Equipment	15
People	16
Environmental	17
Equipment Recovery	18
APPENDIX A - Additional Guidance Material	19
A1 LINE OF SIGHT OPERATIONS	19
A2 TELEREMOTE OPERATIONS	20
A3 MINE PLANNING and DESIGN	22
A4 PEOPLE	23
A5 ENVIRONMENTAL	24
A6 EQUIPMENT	25
A7 MAINTENANCE	26
A8 SAFE WORK LOCATIONS	27
A9 RECOVERY	28
APPENDIX B - MANUAL AND REMOTE CONTROL LHD OPERATION	29
APPENDIX C - EXAMPLES OF LINE OF SIGHT LHD OPERATIONS	30
APPENDIX D - EXAMPLES OF TELEREMOTE LHD OPERATIONS	34
APPENDIX E - TYPICAL BUNDING OF OPEN DRAWPOINTS	37
APPENDIX F - SAFE WORK PROCEDURE - REMOTE LHD FUNCTIONAL TEST SHEET	38
APPENDIX G - EXAMPLES OF REMOTE CONTROL LHD CHECK SHEETS	43
FORM G1 - LINE OF SIGHT CHECK SHEET	43
FORM G2 – TELEREMOTE LHD CHECK SHEET	45
FEEDBACK SHEET	46

Purpose and Scope

This purpose of this Guideline is to provide information to assist in the management of risks associated with the use of remote controlled mining equipment in underground metalliferous operations. The scope of this guideline is limited to issues relating to work system design, equipment operation, equipment, maintenance, environmental and people issues. Technical guidance for the design of remote control equipment is given in AS/NZS 4240 Remote Controls for Mining Equipment.

This Guideline applies to remote controlled mining equipment used in underground metalliferous mines and focuses on Load Haul Dump (LHD) equipment. The guideline covers the use of both 'Line of Sight' and 'Teleremote' systems throughout its operational life cycle, from arrival at the mine, to transport underground, installation, commissioning, operation, maintenance and repair and disposal from the mine.

These guidelines do not apply to the following equipment:

- Cranes
- Shaft and drift winders
- Special purpose equipment
- Conveyor systems
- Automatic guidance vehicle systems

It is important to note that:

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

Glossary

AS - followed by a designation refers to the Australian Standard having that designation that is published by the Standards Association of Australia and includes a reference to that standard as at the commencement day

Back - the roof or upper part in any underground mining cavity.

Brow – the leading edge of an opening at the point where a stope or other opening commences

Bund – a safety barrier usually built of broken rock that is installed near a vertical opening to prevent access into the opening

Checklist - a reminder of what you're looking for and a record of what you found

Communication - process of passing on information in a variety of ways so that the receiver understands the same message as the transmitter intended to give

Competent person – a person who has acquired through training, qualification, or experience, or a combination of these, the knowledge and skills qualifying that person to operate the particular equipment to the current industry competency standard

Competency - ability to apply appropriate skills and knowledge for the effective and efficient completion of a job or task in a variety of situations

Cuddy – deliberately cut place of refuge in a drive or drawpoint for the remote control operator to stand

Danger – a state or condition in which personal injury is reasonably foreseeable

Exclusion zone – means a restricted zone around operating remote equipment that is under the control of the remote operator

Development – any combination of shafts, drives, cross-cuts, inclines and declines by which an underground mining operation is opened up

Drawpoint – opening into the bottom of a stope through which the ore from the stope is extracted

Electronic Barrier – is an automatic system that shuts down the remote controlled equipment if the barrier is passed. Typical barriers are light curtains or physical gates with electrical interlock switches.

Emergency exit - means an exit other than the usual means of access to or egress from a place

Escape Way – a means of exiting the level/mine in the event of an emergency, identified by signage

Exposed person – means any person wholly or partially in an exclusion zone

FFP – fit for purpose

Ground control - the ability to predict and influence the behaviour of rock in a mining environment, having due regard for the safety of the workforce and the required serviceability and design life of the openings

Hazard - a source of potential harm

ITP – inspection and test plan

JSA – job safety analysis

Knowledge – ability to obtain and retain theoretical information relating to a specific subject and being able to research further information

LED – light emitting display

Load haul dump (LHD) – underground mobile equipment used to load and relocate materials

Line of sight – where the remote controls are located with the operator who remains within natural visual and audible range of the equipment being controlled

MSMP – Mine Safety Management Plan

Mobile equipment – means equipment used to excavate, load or transport material that moves on wheels, tracks or skids.

Monitor – to check, supervise, observe critically or measure the progress of an activity, action or system on a regular basis in order to identify change from the performance level required or expected

OEM – original equipment manufacturer

Ore pass – means an underground opening through which broken material is transferred, by gravity, from a higher level to a lower level

PPE – personal protective equipment

Risk – the chance of something happening that will have an impact on objectives

Risk analysis – systematic process to understand the nature of and to deduce the level of risk

Risk assessment – the overall process of risk identification, risk analysis and risk evaluation

Risk identification – the process of determining what, where, when, why and how something could happen

Risk management – the culture, processes and structures that are directed towards realising potential opportunities whilst managing adverse effects

Risk management process – the systematic application of management policies, procedures and practices to the tasks of communicating, establishing the context, identifying, analysing, evaluating, treating, monitoring and reviewing risk

SWP – safe work procedure

Safety-Related Circuits – a circuit whose failure can cause an immediate or latent increase in risk

Self-Rescuer (SR) – emergency respirator to provide protection against contaminated air in an emergency

Stope – excavation, other than development, made for the purpose of excavating ore

Teleremote – where the remote controls are located with the operator who generally remains beyond the natural visual and audible range of the equipment being controlled and usually includes the use of television and video equipment

Underground - means having an overlying cover of rock

References

Legislation

- Occupational Health and Safety Act 2000, General Duty of Care
- Mines Inspection Act, 1901 and General Rule 2000

NSW Department of Primary Industries - Mine Safety publications

- MDG 1010 Risk Management Handbook for the Mining Industry
- MDG 1014 Guide to Reviewing a Risk - Assessment of Mine Equipment and Operations
- MDG 5002 Guideline for the Use of Remote controlled Mining Equipment Version 1 1998
- MDG 5001 Guidelines for the Design of Remote Control Systems for Mining Equipment
- MDG 1015 Guideline for Mobile and Transportable Equipment in Mines
- Minerals Industry Safety Handbook – July 2002
- Mine Safety Management Plan Workbook
- National Minerals Industry Safety and Health Risk Management Guideline 2005 (when released – still under development) - www.mishc.uq.edu.au

Standards

- AS 4024 – Safe Guarding of Machinery
- AS 4240 - Remote Controls for Mining Equipment
- AS 4360 – Risk Management
- AS 5062 – Fire Protection of Mobile and Transportable Equipment
- AS 61508 – Electric Electronic Electronically Programmable Safety Systems

Other references

- Safe Mining – CCH Australia Limited
- OEM Manuals
- NSW Minerals Council Induction Guideline
- The Minerals Industry Safety & Health Centre (MISHC)

General

Management systems for the use of remote control mining equipment 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 planning, management and operational steps identified in this Guideline should, where appropriate, be developed in consultation with mine design engineers, equipment suppliers and maintainers, equipment operators and supervisors. These should be considered when developing hazard controls and safe systems of work for remote control mining equipment operations.

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

Safe work systems for the use of remote controlled mining equipment should be determined by a risk management approach. All hazards associated with the use of remote control mining equipment should be identified, assessed and eliminated or adequately controlled by applying the hierarchy of controls.

Record keeping and documentation

The records and documentation of the design, planning, development (if applicable) and operation of remote control mining equipment should be integrated with the MSMP document control system. Accurate records should be kept of all stages of the remote controlled mining equipment operation, from the initial stope design stage to the selection, purchasing and commissioning and use of remote controlled equipment. Particular documents that can be considered may include:

- documented risk assessments associated with the mine planning process. Should include selection of a mining method (stope design) that provides a safe work environment for remote controlled equipment operator
- safe work procedures for repetitive or high risk activities
- records of remote controlled equipment selection process and purchase details
- records of operational checks
- records of workplace inspections
- testing and maintenance records for remote controlled equipment, including remote control receiver, transmitter and ancillary equipment
- records of training and competency assessments
- records of hazard reporting and follow up
- audit and monitoring records
- pro forma documents for daily and regular checks on equipment functionality – based on the risks identified

Training

The MSMP should include a training plan that ensures remote controlled equipment operators, supervisors and maintenance personnel are trained and competent to perform the tasks required of them. Training should include a documented training assessment process that includes both a practical and theory component. This may be a component of a Safe Work Procedure competency based assessment. A reassessment program should be included in the training plan. Training and skills should be recorded on each operator's personnel files.

Monitoring, systems audit and review

Remote control equipment operations and procedures should include an auditing and review process to ensure required procedures and standards are being complied with. The auditing and review process should be part of the continuous improvement process under the MSMP. This includes action to:

- monitor record keeping
- audit procedural compliance
- audit implementation of remedial action from hazard identification
- analyse results, both routinely and after unplanned movements or incidents /accidents involving remote control equipment
- feed outcomes from analysis back into future planning and operational processes
- integrate the monitoring and review of remote control operations and procedures into the MSMP review and continuous improvement process

Risk identification and assessment

The following section lists the main hazards associated with the use of remote controlled mining equipment in underground metalliferous mines 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. Additional information that may assist the risk management process is contained in Appendix A - Additional Guidance Material. It provides supporting reference material and tables key system elements, issues to be considered and possible controls. For more information on how to conduct and review a risk assessment refer to MDG 1010 Risk Management Handbook and MDG 1014 Guide to Reviewing a Risk Assessment of Mine Equipment and Operations.

REMOTE CONTROLLED MINING EQUIPMENT

Line of Sight Operations

Required outcome

Line of sight remote controlled equipment operations are undertaken in a safe and efficient manner. Due to the hazards associated with line of sight operations a detailed risk assessment should be carried out prior to the commencement of line of sight operations. The risk assessment needs to consider each of the main risks that are set out below and in the following sections. A detailed action plan should then be developed and implemented to ensure that line of sight operations do not expose personnel to any intolerable risks from the use of such equipment.

As part of the risk assessment process the use of teleremote equipment should be considered to mitigate the hazards associated with the use of line of sight equipment.

Main risks

- unplanned movement of remote controlled equipment
- personnel in close proximity to equipment being operated on remote control
- remote operator location during change over from remote control to manual operation and vice versa – operator not sufficiently clear of equipment during change over
- change over position located too close to open brow and/or under bad ground
- operator does not follow change over standards/procedures
- material falling from LHD bucket
- remote control operator unaware of unauthorised personnel in the exclusion zone
- operator unable to effectively communicate with other personnel – eg in the case of an emergency
- manually driving equipment into open stope or under bad ground - the operator does not have the training or competency to determine when to go onto remote control operation
- falling rocks, inrush or engulfment by other material and potential airblast while working near an open brow
- inspection of open drawpoints and stope voids - lack of a system that allows remote inspection of drawpoints and stope voids
- plans and safe work procedures not available or not used by remote operators
- inexperienced operators or supervisors signing off on remote control shift procedures ie JSA/SWP
- pre-start and mid shift remote equipment checks not conducted, recorded or submitted at end of shift
- untrained personnel operating remote control equipment - lack of a competency based training and assessment program for remote controlled operations
- inappropriate barrier selection or use
- incorrect selection of the risk assessment team for remote control operation
- remotely controlled machinery becoming “stuck” in draw points or stope voids where they can not be safely accessed by an operator

Main risk considerations

- consider the use of teleremote operations
- develop and implement site specific change over standards/procedures that set out the location at which the operator takes manual control of the equipment and vice versa to ensure that there is no risk to the operator in the event of a hazardous or unplanned movement
- development of site standards and competencies for the identification of the potential hazards around open drawpoints and brows - consider risk associated with proximity to an open brow
- development of a competency based training program and review process
- development of a system that allows inspections of drawpoints to be carried out without exposing personnel to an open brow
- develop a process to ensure all personnel have access to the relevant documentation, ie safe work procedures, risk assessment results and plans
- implement a process to ensure that pre-start and mid shift checks are conducted and recorded correctly
- remote control equipment should be shut down during the process of accessing and egressing the equipment
- remote to manual and visa versa change over point to be determined by the use of a risk assessment
- risk assessment process should consider proximity of backfilled voids and other workings including possible water content/particle sizes etc in voids
- the location of the operator during remote control operations shall be included as part of the risk assessment
- develop and implement access and entry procedures to the exclusion zone
- exclusion zones clearly marked up in the work area and displayed on plans and signed off prior to remote operations commencing
- communication infrastructure and systems available for the remote control operator eg mine wide radio and or telephone systems
- barrier system design, installation and use should be included as part of a risk assessment and utilise the requirements of AS 4024 or other standards as appropriate
- barrier system to be signed off by a competent person/engineer
- risk assessment team selection to be undertaken as per the requirements set out in MDG 1010 or equivalent with particular attention being paid to the team selection
- the machine and associated equipment should conform to the requirements of AS 4240
- remote control training requirements should be included in the MSMP training section
- equipment capable of retrieving remote controlled equipment from unsafe areas without requiring personnel to enter those areas should be available

Teleremote Operations

Required outcome

Teleremote controlled equipment operations are undertaken in a safe and efficient manner. Whilst the use of teleremote systems reduce the hazards to the operator due to the removal of the operator from the immediate remote equipment work area the risk of unauthorised access is potentially increased. However an emphasis on personnel access into the teleremote operating area should be considered due to the possible remote location of the teleremote operator. The line of sight risks and considerations should also be considered when reviewing the risks for teleremote operations to see if they apply.

Main risks

- unauthorised access to teleremote exclusion zone whilst teleremote equipment is in operation
- failure of or ineffective barrier system allows unauthorised access to the teleremote operating area
- inappropriate teleremote equipment operation due to poor or no training
- inadequate equipment clearance for the correct operation of the teleremote equipment
- incorrect selection/installation of barriers for the teleremote system
- barrier system could potentially fail to operate when required – incorrect CAT rating selected
- barrier system does not meet the requirement of AS 4024 - integrity of the barrier system is insufficient
- personnel within the barrier system when teleremote operations commence
- deterioration of the work environment due to use of teleremote operation
- teleremote equipment violates the barrier system with insufficient distance to stop the equipment contacting personnel outside the barrier system
- operators unable to determine status of barrier system without physical checks
- equipment collision during teleremote operation
- unable to control fire on teleremote equipment during teleremote operation – fire suppression system does not comply with AS 5062

Main risk considerations

- MDG 1010, AS 4360 standard risk assessment to be carried out prior to the commencement of teleremote equipment operation. Risk assessment should address conformance with AS4024, and consideration should be given to other workplace activities that are required in the area
- distance between the barrier/s and the other personnel should be included in the risk assessment
- develop appropriate monitoring and audit systems for the barrier system
- remote status of barrier system should be available to the teleremote operator or other personnel in the work area
- ensure conformance with AS 4024 minimum CAT 3 rating – verification and validation plan
- include the requirement for a traffic management system as part of the risk assessment
- components of the teleremote system in common with the line of sight components should conform to AS4240 including the fire suppression activation system
- the fire suppression system should confirm to AS 5062
- pre start inspections should include checking the work area to ensure that no personnel are inside the barrier system prior to commencing teleremote operations
- isolation system for the barrier system and associated remote equipment should be developed in compliance with AS 4024

Planning and Design

Required outcome

The planning and design process should evaluate all possible mining and associated remote controlled equipment options with the view to providing the safest working environment for remote controlled equipment operators for the life cycle of the mining operation. Consideration to the use of line of sight and/or teleremote operations needs to be reviewed in the initial mine design process. Mine design engineers should ensure that consideration is given to providing a safe work location for remote control mining equipment operators.

Main risks

- Inadequate risk assessment at the design stage. Specific issues to assess:
 - design and location of safe work locations for teleremote operators
 - exposure to other personnel who may enter remote operating areas
 - OEM specifications not reviewed during design process
 - geotechnical and airblast hazards
- inappropriate selection of the remote control system
- poor designs results in development not fit for purpose for remote equipment. Issues include:
 - drawpoint too small in size and/or too short in length
 - drawpoint too wide – potential for poor ground conditions at brow and in drawpoint
 - truck loading areas - risk to equipment operators whilst remote controlled equipment operating in the vicinity
- teleremote operating zone located in or near a thoroughfare where manual traffic requires regular access eg in close proximity to maintenance facilities, pump stations etc

Main risk considerations

- stope and development designs to be the outcome of a formal design process with appropriate system reviews and audits
- competent persons to be engaged in the design process and to be aware of remote controlled equipment systems requirements
- risk assessment to MDG 1010, AS 4360 standard as part of the design process.
- stope designs should minimise the use of remote controlled equipment
- evaluation of geological and geotechnical issues are conducted by competent persons
- verification and validation plan for the mine design should review the remote control equipment requirements
- teleremote operating zones should be located where minimal access is required by people ie minimum through traffic.

Safe Work Locations

Required outcome

A safe work location should be included as part of the mine design process to ensure that a safe area is available for the remote operator to stand/sit whilst operating remote controlled equipment. The remote operator work location should be designed in such a manner that ensures the remote controlled equipment cannot come into contact with the operator under any circumstances.

Main risks

- no safe work location available - remote operator and other personnel come in close proximity to operating remote controlled equipment
- unauthorised entry into the remote controlled equipment exclusion zone
- inadequate construction/design/position/poor ground support in remote control work area
- cuddy is too small for adequate entry for the remote operator
- cuddy is too big for the application and will allow the remote controlled equipment to enter the cuddy
- cuddy is too close to brow / too far away for remote operator to safely observe remote controlled equipment operation
- remote operator is exposed to falling rocks / poor ground conditions
- the size and location of physical barriers are too small and incorrectly located for the size and speed of the remote controlled equipment
- inadequate dust control systems and poor ventilation system causes dust and fumes to remain in the work area
- poor housekeeping in remote operator work area and in and around cuddy (if used) - potential for slips, trips and falls while operating remote controlled equipment
- cuddy design location is inadequate to allow the operator effective visibility of the remote equipment

Main risks considerations

- formally risk assess each remote equipment operating area to ensure an adequate safe work location is available – remote operations should not take place without provision of a safe work location for the remote operator
- develop and implement safe work procedures, based on formal risk assessments, which control the unauthorised entry of personnel into exclusion zones
- stope and development designs to be the outcome of a formal design process with appropriate system reviews and audits
- competent persons to be engaged in the design process and to be aware of remote control equipment systems requirements
- MDG 1010, AS 4360 risk assessment process to develop site specific procedures/standards. The characteristics of the remote controlled equipment are to be considered as part of the design of all physical barrier systems
- ventilation systems are designed and installed prior to remote control operations commencing
- remote operator work areas and cuddy floors (if used) to be designed, installed and maintained to ensure safe footing for the operator
- cuddy design precludes access by remote controlled equipment
- validation and verification plan for the cuddy design and location

Maintenance

Required outcome

The maintenance program for the remote equipment should ensure that remote equipment is maintained and inspected in such a manner that guarantees the equipment remains fit for purpose. The maintenance schedule in addition to regular servicing should also include a reporting system that allows the operator to report faults and defects and, if necessary, remove the unit from service.

In the event that modifications or component changes are required a documented process for tracking and testing should form part of the maintenance documentation.

Main risks

- maintenance checks not undertaken or actioned
- failure of a safety related system
- OEM manuals not read and or not provided or up to date
- failure to identify safety critical control circuits
- maintainers not competent to maintain remote equipment
- equipment not maintained to the OEM standards required for remote equipment
- equipment not isolated correctly during maintenance activities
- approaching remote equipment without prior communication with remote operator (barrier failure)
- the correct systems and procedures are not in place for the piece of equipment ie maintenance competency, operator training, spare parts and testing procedures
- no documented Inspection and Test Plan (ITP) for the remote controlled equipment
- re-commissioning not carried out following maintenance activities - no verification checks of the remote system
- remote operator unaware of functional failure with the remote system
- no systematic check of the remote system ie functional checks and output verification eg LED on outputs
- functions may not be correct for the action selected ie bucket up activated - bucket goes down
- lack of competency and equipment to diagnose remote system problems

Main risk considerations

- develop a detailed set of ITP's/functional checks for the remote equipment
- develop a planned maintenance plan that complies with the requirements of the OEM standards, Australian Standards and relevant site standards
- develop a detailed life cycle plan including maintaining the associated equipment and infrastructure for the remote system
- develop a commissioning plan for the remote system following maintenance which includes the testing of the safety related functions
- develop a pre-start/mid-shift check sheet and associated procedure
- develop a detailed test procedure and JSA system for maintenance tasks
- develop isolation procedures specific for remote controlled equipment
- develop and train maintenance personnel to the required level of competency
- develop procedures, infrastructure and systems to preclude maintenance personnel from entering the remote equipment operation area while remote equipment is operating
- develop a system to ensure that maintenance personnel have access to the most up to date and relevant information on the remote systems
- safety critical components should be clearly identified and communicated to the maintainers as part of the training program and ongoing documentation system
- develop competencies for the operators to ensure they are aware of any functional failures of the remote system including the various reporting processes

Equipment

Required outcome

Remote equipment should comply with all relevant Australian Standards whilst being fit for purpose. The units shall be designed to allow the operator the most flexibility and comfort whilst ensuring the interface is ergonomically designed to take into account operator exposure time.

Main risks

- incorrect selection of the remote system and equipment
- remote controlled equipment is not fitted with the required safety devices
- the remote system and equipment may not have the necessary safety devices for shutdown or operator protection
- inappropriate barrier system – ie concrete blocks used instead of infra red curtains etc
- initial equipment commissioning not carried out prior to use (no verification checks of the system)
- no system to manage the various radio frequencies across site
- no mine communication equipment available for use by remote controlled equipment operators eg radios, telephones etc
- barriers do not comply with AS 4024
- remote controlled equipment does not comply with AS 4240

Main risk considerations

- ensure detailed specifications for the supply of the remote controlled equipment are available
- develop a detailed life cycle plan including the associated infrastructure for the remote controlled equipment
- carry out detailed FFP audit including the requirements to comply with AS 4240 prior to use
- develop a detailed set of ITP's/functional checks for the remote equipment and systems
- ensure MDG 1010, AS 4360 risk assessment process used to develop site specific remote equipment selection and purchase procedures
- carry out detailed risk assessment for the barrier system and where possible achieve compliance with AS 4024
- develop a commissioning plan for the remote equipment prior to use
- develop a pre-start and mid-shift check sheet with associated reporting procedure
- develop and train personnel to required level of competency and ensure competent personnel carry out ITP's etc
- ensure a system exists on site that manages the various radio frequencies and associated spectrum management system
- ensure equipment is available that allows remote operators to communicate effectively with other personnel
- barrier systems and personnel protection devices should comply with the requirements of AS 4024 and where appropriate AS 61508

People

Required outcome

Remote controlled equipment is highly specialised and should only be used and maintained by adequately trained and competent personnel. Remote controlled equipment operators need to be fully aware of the hazards and risks involved with the use of such equipment. Effective consultation and communication systems need to be integrated into the overall remote control equipment management systems to ensure the equipment is operated safely, efficiently and effectively. The operator interfaces are available in a range of configurations, control types, sizes and weights that need to be ergonomically assessed prior to use. These units whilst of a rugged construction must be treated with care. The operator who is ultimately responsible for this equipment should be aware of all the site specific and statutory requirements regarding the use and care of remote controlled equipment.

Main risk

- significant human error hazards not identified, assessed, communicated or corrected
- remote controlled equipment not ergonomically designed or assessed
- documented action plans not followed up and implemented
- remote operator unable to communicate with other personnel in the case of an emergency – communication systems located in remote equipment and operator located outside equipment
- unauthorised access to remote control area due to a poor induction process
- inappropriate behaviour of personnel around remote equipment – lack of awareness regarding the hazards associated with remote control equipment
- remote equipment not isolated correctly – remote control energy sources not effectively identified or understood
- emergency escape route is not identified as part of the mine design process
- no competency standard for supervisors with regards to remote control equipment operation
- remote operators and supervisors unaware of responsibilities and authority levels with regards to remote equipment operation and internal/statutory reporting requirements.
- no system or procedure in place to allow communication with the remote equipment operator or people in the vicinity of operating remote controlled equipment

Main risk considerations

- ensure human error hazards are identified, analysed and actioned during remote control equipment risk assessments
- ensure ergonomics and control layout are considered in purchase of equipment
- ensure comprehensive safety and health systems are developed for remote control equipment operations including - document control, employee/contractor inductions, hazard identification, training etc
- communication infrastructure for the remote control operator should be included as part of the risk assessment
- conduct task observations of remote control equipment operations to ensure correct behaviour and compliance with procedures
- emergency management plans for remote control operations developed and effectively communicated to all personnel
- develop competency based training programs for remote control operators and supervisors – to include internal/statutory reporting requirements

Environmental

Required outcome

A work area that provides a safe place to work free of environmental hazards such as noise, dust, atmospheric contaminants, poor ground conditions, poor lighting etc.

With line of sight operation the operator has been removed from a secure cabin located on the equipment and is now free to interact with the local environment in a much broader manner. This may subtly or quite dramatically change the risk profile to the operator. The traditional, well established risk controls for normal equipment operation may no longer apply. A typical example is that the operator now has the potential to be crushed by the remote controlled equipment that they are operating. They are also exposed to other risks such as poor ground conditions, noise, dust and other atmospheric contaminants while operating the equipment on remote control. The hazards to line of sight operators while located outside the equipment cabin needs to be clearly identified, fully understood and critically assessed to ensure the a safe work location is provided for the operator.

Main risks

- noise levels in remote operating area exceed allowable exposure limits eg ventilation fans, LHD operation, drilling activities
- stope fails or rills producing dust and/or airblast
- exposure to heat stress and fatigue
- loss of control of remote equipment due to a conflict of frequencies
- ignition of undetonated explosives during the mucking cycle which exposes the operator to the effects of the blast
- concurrent activities within the remote operating area
- exclusion zone not clearly identified or communicated
- in an emergency the operator cannot gain access to an egress point or refuge chamber
- pollutants from the remote equipment and/or blasting operations
- deterioration of ground conditions within the remote operating area – adjacent drawpoint rills

Main risk considerations

- consider the use of teleremote operation
- locate noisy equipment outside remote operating area (eg ventilation fans, drill rigs), have good mine planning and scheduling (eg flow through ventilation systems, drilling conducted prior to remote operations commencing), purchase equipment with low noise emissions and maintain to high standards
- provide effective dust suppression systems
- use of appropriate PPE
- implement a stope monitoring program with appropriate trigger levels to remove personnel from potential ground falls and airblast situations
- provide effective ventilation systems, fatigue management process which may include job rotation
- spectrum management system needs to ensure that there is no conflict of frequencies
- implement re-entry after blasting and misfire procedure. Ensure remote operating position is an adequate distance from muck pile and open drawpoint
- control other activities in remote operating area and limit access when remote operations taking place
- clearly identify exclusion zones and implement procedures to ensure personnel are aware of what the implications are of entering exclusion zones
- remote area layout to ensure operator has access to emergency egress. Consider emergency escape as part of the risk assessment process
- correct identification of the transmitter and receiver that is machine specific
- implement check scaling program for the remote operation areas and restrict access to the drawpoints - consider regular geotechnical assessment, ground support regime, drawpoint barricading etc

Equipment Recovery

Required outcome

Remote control equipment is recovered safely and effectively from a hazardous area.

Main risks

- unauthorised recovery attempts carried out
- inappropriate infrastructure and equipment available for assessment of trapped equipment
- no system exists for the isolation of the equipment for recovery operations
- failure to carry out JSA /risk assessment prior to commencing recovery attempts
- other activities not considered as part of the isolation/JSA/risk assessment process
- incorrect selection of the risk assessment team
- non compliance with Australian Standards and sound engineering principles during recovery efforts
- remote controlled equipment not fitted with brake release system
- no system exists for the inspection and maintenance of recovery equipment prior to use and following recovery
- no system exists to ensure the JSA/risk assessment is carried out as per the documented action plan
- no system exists for the functional checking of recovered equipment prior to the recommencement of remote operation
- recovery issues not considered in initial design, purchase process

Main risk considerations

- risk assessment team selection to be undertaken as per the requirements set out in MDG 1010 and/or AS 4360
- recovery equipment should be included as part of the maintenance program,
- ensure remote controlled equipment fitted with a brake release system and recovery attachment points etc
- implement a system to ensure a JSA/risk assessment is used and checked on the job. If the task changes the JSA/risk assessment should be reviewed and amended
- recovery equipment to be stored separately and only used for the dedicated purpose of equipment removal – this equipment should be colour coded or tagged to ensure that the slings, chains are not confused with standard lifting equipment
- safe and rapid response to allow the use of the motive power of the trapped machine

APPENDIX A - Additional Guidance Material

The contents of this appendix should be used as additional input into any risk management process associated with the use of remote controlled mining equipment in underground metalliferous mines. 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 circumstance.

The material covers major areas of the use of remote controlled mining equipment as identified by a New South Wales underground metalliferous industry working group.

It is particularly important that risk assessments and the development of hazard controls include a review of all areas of remote controlled equipment operation as identified by MDG 5002 and the additional guidance material contained in this appendix. The principles objectives of this appendix is to identify issues that should be considered in developing safe systems of work for the use of remote controlled mining equipment in underground metalliferous mines.

A1 LINE OF SIGHT OPERATIONS

Activity	Issues to be considered	Notes and Possible Controls
Storage of equipment	Potential to damage remote transmitter, ie run over or inadvertent operation by unauthorised personnel.	Consideration to providing a secure storage location for the remote control transmitter during manual operation.
Access to equipment	Damage to handrails and steps on remote controlled equipment during operation.	Potential for - slips trips and falls / uneven surfaces / falling rocks / poor housekeeping ie dirt or rocks on steps / poor hand holds / uncontrolled vehicle movement/not maintaining 3 points of contact.

A2 TELEREMOTE OPERATIONS

Activity	Issues to be considered	Notes and Possible Controls
Initial teleremote set-up	No area suitable for the location of the teleremote control room.	Ensure the design and development of adequate areas for the location of teleremote control rooms are included in mine design plans and schedules.
	Ergonomic design for the long term exposure for the operators.	Poor selection of teleremote equipment exposes operators to poor ergonomic layout. Ergonomic considerations need to be addressed at the purchase stage.
	Data requirements for the remote system exceeds capacity of the backbone system.	Backbone design needs to be included as part of the initial design process.
	No indication of barrier status to personnel in operating area.	Requirement for visual indication of barrier status.
	Lack of suitable induction/notification of teleremote operation.	Ensure effective communication is undertaken with the workforce regarding the use of teleremote equipment eg tool box sessions, inductions, shift change over meetings.
	Lack of appropriate communication system/s for the operator.	Consideration should be given to the need to provide good communication infrastructure and systems for teleremote operations during the mine design and equipment purchase phase of the process.
	Insufficient power/communication systems to operate teleremote equipment.	Plan for and install adequate power and communication infrastructure to meet the needs of current and future teleremote requirements.
Barriers	Personnel unaware of teleremote operations taking place leading to inadvertent access to teleremote operating area.	The location of the teleremote barriers should be identified by appropriate signage and or warning lights to notify personnel that teleremote control operations are taking place in the area. Induct and assess underground personnel's knowledge on the dangers of entering teleremote control operating areas.
	Inadvertent trip of teleremote controlled equipment barriers.	Adequate lights around barrier access areas and system to indicate status of barrier/s.
Operators	Operators exposed to TV monitors for long periods of time. Long term exposure to monitors could lead to degradation in operator's health.	Develop an exposure and fatigue management system that considers the effects of exposure to TV monitors/fatigue on teleremote operator's health.

Activity	Issues to be considered	Notes and Possible Controls
	Design of the operator's station to consider the various physical attributes of all operators. Failure to consider all physical attributes could result in RSI or similar conditions.	Assess and monitor each operator's physical condition and consider purchase and installation of ergonomic equipment.
Teleremote Equipment	Operators unable to determine status/functionality of the remote controlled equipment.	Consideration should be given to the type, location and amount of cameras fitted to the remote controlled equipment ie black and white, colour, PTZ The system design should address the requirement for the quality and type of cameras to be used during teleremote operation.
	Failure of the communication system.	Consideration should be given to the location of the ariels on the remote controlled equipment to reduce the exposure of the ariels to damage during normal operation.
	Damage to the teleremote equipment in the event of mechanical failure ie hydraulic hose failure, fire system initiation.	Remote system should include a shutdown system for equipment critical alarms which results in the machine being left in unsafe ground.
	Incorrect operation of the remote controlled equipment.	The directional response of the steering should be consistent with the viewpoint of the operator watching the video images. ie if the operator moves the joystick left, the vehicle will turn left from the view-point of the camera facing in the direction of travel (the observer). Other remote control configurations should be the same as the remote controlled equipment.
	Damage to the remote controlled equipment during operation ie running over a rock and damaging the equipment	Teleremote functionality should allow for general clean up and road maintenance.
	Operator unable to determine exact location of the remote controlled equipment during production cycle.	Design of tramming route should include a system to allow for absolute reference of the teleremote equipment. Such as clearly marked reference points along tramming route.
Work area	Inappropriate selection of work area for operator's station.	Develop standards for the location of the operator station ie control room UG/Surface/mobile operators station and associated infrastructure requirements ie tables, operators chairs etc
	Poor quality ground conditions preclude access to teleremote tramming area.	Application of the same standards in tramming area as for the remote operators station ie scaling, ground control, housekeeping etc

A3 MINE PLANNING and DESIGN

Activity	Issues to be considered	Notes and Possible Controls
Design	Ventilation system requirements.	Ventilation system design should consider providing a primary one pass flow through system to remote control operating areas. Secondary ventilation systems should be avoided for line of sight operations. Consideration should be given to dust control/extraction methods and operator visibility. Ventilation exhaust paths should consider smoke paths in event of a fire in remote control work location.
Design	Geological/geotechnical assessment. Inadequate geological and geotechnical evaluation creating an increase in the risk of falling ground during remote control equipment operations.	Ground conditions can be assessed during stope development and production drilling. Ground support systems need to be designed and installed by competent persons to ensure a safe work location is provided for remote controlled equipment operators. This may require additional ground support in safe work area eg shotcrete, meshing etc
Design	Requirement for through traffic.	Consideration should be given to the location of teleoperation zones so that normal mine traffic including equipment and pedestrians does not cause frequent cessation of teleremote production or temptation to bypass of barrier system.
Scheduling	Production pressures and inaccurate scheduling may result in stope's coming on line and requiring use of remote control equipment before all services and ground support are installed.	Early identification of the need for the use of remote controlled mining equipment in the design and planning schedules will allow the assessment and installation of effective management systems. This should include assessment of the remote control method eg line of sight and or teleremote systems and the provision of safe work locations prior to production operations commencing. Eg cuddies incorporated in initial stope design and installed and supported during initial stope development
Scheduling	Unplanned significant changes to ventilation systems.	Ventilation systems should be fully operational prior to remote control operations commencing.
Communication	Voice and data communications for operators of remote controlled equipment.	Communication not available to remote operator whilst on remote's at all times – consider communication system design, purchase and installation requirements in mine design process.

A4 PEOPLE

Activity	Issues to be considered	Notes and Possible Controls
Training	No review process for the training competencies required by remote control equipment operators.	Maintain up to date competencies - for remote operators, maintenance personnel and supervisors. Conduct regular reviews of competency levels including task observations. Consider regular reassessment programs.
	No system exists for the practical training of remote control equipment operators and maintenance personnel.	Consider the need for simulation package to allow the training of operators and maintenance personnel. Develop a training system that includes a practical training and assessment process for remote control equipment operators and maintenance personnel.
	Risks associated with remote controlled equipment are not included in the Mine Safety Management Plan.	Ensure that an appropriate section on the operation of remote controlled equipment is included in the Mine Safety Management Plan.
	Inappropriate selection of personnel operating remote control equipment.	Consideration should be given to the physical condition of personnel who will operate remote control equipment.
	Human error.	Conduct and implement findings from potential human error identification and risk assessment.

A5 ENVIRONMENTAL

Activity	Issues to be considered	Notes and Possible Controls
Operating on remote control	Line of sight operators may be exposed to high levels of dust contamination from the operation of remote controlled equipment, poor ventilation, stope riling etc.	As part of the remote site establishment, provision of effective dust suppression systems should be made. This may consist of <ul style="list-style-type: none"> ▪ installation of water sprays ▪ installation of an effective flow through ventilation system ▪ not using auxiliary ventilation fans to ventilate remote operating areas ▪ installation of effective ventilation controls to direct dust through stope or away from operating areas, seal travel ways with dust suppressants ▪ provision of effective PPE
	General lighting in the area from the remote controlled equipment and the operating area. Poor visibility whilst operating remote controlled equipment.	Consider the installation of effective lightening systems on remote controlled equipment and in remote operating area.
	Line of sight operator becomes fatigued during the operation of the remote equipment due to operating conditions, weight of the remote set and other external conditions.	Controls may include <ul style="list-style-type: none"> ▪ fitness for work policy that addresses fatigue issue of remote control operators ▪ job rotation during the shift ▪ use of teleremote equipment
	Loss of control of remote controlled equipment due to the poor road conditions within the remote operating area.	Controls may include <ul style="list-style-type: none"> ▪ documented workplace inspection process to assess road condition prior to operating equipment on remote control ▪ implementation of a planned roadway inspection and maintenance program
	Access to PPE by the remote control equipment operator.	Ensure remote control equipment operators have access to appropriate PPE - ie spare SR unit in LHD, hearing protection – sound proof operator cabin (teleremote), eye protection, dust masks etc
	Acceleration of fatigue due to the amount of PPE the operator may have to wear whilst operating remote equipment ie safety glasses, SR, hearing protection, dust masks, cap lamp, hard hat etc	Consider teleremote method, regular breaks, job rotation etc Develop and implement fatigue management plan for remote control equipment operators.
	Barricading is difficult to use and set up.	Remote areas barricading should allow easy set up and testing as part of the remote operation.

A6 EQUIPMENT

Activity	Issues to be considered	Notes and Possible Controls
Remote controlled equipment	Remote controlled equipment is not fit for purpose.	Technical specifications of the remote equipment should be included in the purchase contract to ensure that the equipment is fit for purpose.
	Remote controlled equipment does not meet the requirements of the site and the intended application.	Consider conducting Fit for purpose audit and review prior to delivery of the remote control equipment.
	Manuals not available to the operators or maintainers for the remote system - Incorrect or poor quality manuals for the remote system - Manuals not kept up to date with service bulletin changes for the different remote's.	Ensure OEM manuals are supplied with all remote controlled equipment (new and second hand) and readily available. Manuals need to be maintained up to date.
	No register of remote control equipment is maintained.	A register of all remote controlled equipment should be maintained on site. Every piece of remote controlled equipment should have the brand, type, serial number, frequency etc recorded in a register. The register is to be kept up to date.
	Identification of remote control equipment.	All remote controlled equipment should be clearly marked with individual serial numbers eg transmitters and receivers.
	Development of planned maintenance systems.	Failure to comply with vehicle emission testing programs
AS 4240 Compliance	Compliance with AS 4240	Power output of the system may be too high (wattage set to high to allow close proximity to explosive).
	Remote control equipment non compliance with AS 4240.	Conduct pre and mid shift checks of the remote controlled equipment and safety related systems.
	Fire on remote controlled equipment and remote system not fitted with fire activation system ie non compliance with AS 4240.	Ensure that remote fire activation system is fitted to remote control equipment and system regularly inspected, tested and maintained to minimise the risk of uncontrolled fires on remote controlled equipment.
Commissioning	Commissioning procedure and associated documentation. Commissioning procedures not documented.	Develop safe work procedures for the commissioning of remote control equipment. The safe work procedures should be developed after completing a risk assessment. All identified commissioning hazards to be documented, controlled and communicated prior to commissioning commencing.
	Accuracy of simulation testing and training.	Ensure simulator regularly checked and calibrated to ensure accuracy of test result.
	Trouble shooting a problem with the remote controlled system.	Consider allocating an area for the testing/commissioning of the remote equipment for faults. Consider having an operator in the equipment cabin during testing/commissioning to manually control any unintentional movement.

A7 MAINTENANCE

Activity	Issues to be considered	Notes and Possible Controls
Maintenance	No documented system for the isolation of the remote control system. No provision for isolation of the remote system ie no location that allows the system to be locked out.	Ensure adequate isolation procedures developed and documented for isolation of all remote controlled equipment on site. Ensure all remote controlled equipment has adequate isolation points.
	Correct transport of the remote equipment.	Develop documented procedures for the correct transportation of remote control equipment on site.
	Safe storage of remote equipment. No allocated area for the storage of the remote units when not in use. Possible damage by moisture, dust, rock falls, temperature etc.	Develop and implement procedures for correct storage of remote control equipment.
	Flat batteries results in down time, remote equipment stopping in hazardous area.	Develop battery management system for changing and charging batteries etc ie may require more regular battery change outs. Ensure correct battery/ voltage - charging locations availability.
	No ability to carry out functional checks of the remote system off the machine.	Consider using a simulator for the testing of the remote control equipment.
	Diesel exhaust emissions in remote control operational area affects remote operator.	Ensure remote equipment fit for purpose. Consider use of electrically operated equipment, develop ventilation management systems, and ensure regular testing and monitoring of diesel exhaust emissions.
	Failure of a pre-start warning device.	Ensure pre start warning device fitted and functioning correctly – regularly inspected and maintained.
	Hazards not identified/actioned during maintenance activities - records not retained	Ensure formal hazard identification and control system developed and effectively implemented for remote control equipment maintenance activities – maintenance records maintained and analysed.
Frequencies	Incorrect frequency allocations/settings for remote equipment.	Ensure a system is in place to manage the frequency allocations/setting for remote control equipment and other technical equipment. Ensure no two remote control units on site should have the same frequencies.
	Clashing frequencies on site.	Ensure frequencies management carried out on site - out put power -PED systems.

A8 SAFE WORK LOCATIONS

Activity	Issues to be considered	Notes and Possible Controls
	Line of sight operator is exposed to falling rocks / poor ground conditions.	Ensure that the safe work and change over locations for the operator has been determined by a formal risk management process that includes a physical assessment of the actual work location.
	No plans detailing the location of the physical barriers or cuddies available to the line of sight operator.	Ensure accurate and up to date plans are available that show the location of any physical barriers or cuddy, the change over position and safe work locations for the line of sight operator.
	Line of sight operator is exposed to the remote controlled equipment from different directions.	Ensure assessment of safe work location is conducted relative to the intersection of drives and drawpoints.
	Unsafe operating location when using line of sight equipment.	The general stand-off distance for line of sight operators relative to the remote controlled equipment to be formally assessed for each work location – stand-off distance to be determines by formal risk management process.
	Line of sight operator is located too far from operating remote controlled equipment; visibility is further reduced due to dust in the area.	Ensure good ventilation system in place (to reduce dust and fumes) and additional lighting is available if required. General visibility in the work area for remote operators should be considered as part of the remote area design and set-up process.
	Poor or no workplace inspections conducted.	Lack of inspection process may fail to highlight poor ground conditions / ventilation problems/ dust control issues/ status and effectiveness of safe work location. Ensure formal workplace inspections conducted prior to the operation of remote controlled equipment.
	Operator has poor visibility due to inadequate lighting.	Provide adequate lighting for the operator both in the work area and on the remote equipment.
	Operator is unaware of the drawpoint conditions ie hung and open, rill frozen, large oversize material	Ensure drawpoint and stope conditions accurately recorded and reported from shift to shift. Develop system for inspecting and monitoring drawpoint and stope conditions. Consider remote methods for inspecting/assessing drawpoint/stope conditions eg Cavity Monitoring Systems.
	Location of services are not considered during the mine design process – electrical cables/installations, air and water pipes, fans and vent ducting etc	Location of service's need to be included as part of the mine design process to ensure they do not create a hazard during remote control operations.

A9 RECOVERY

Activity	Issues to be considered	Notes and Possible Controls
Recovery	Checking the location of trapped remote controlled equipment in open stope or other hazardous area. Incorrect location selected by personnel involved in equipment recovery operations when inspecting and assessing location of trapped equipment.	Consider remote methods for inspecting/assessing location of trapped equipment.
	Determining the status of trapped remote equipment ie broken down, out of fuel, flat battery, burst hydraulic hose, buried by rock fall etc. Incorrect assessment made of equipment status.	Develop system for accurately identifying, reporting, recording and communicating status of trapped remote controlled equipment.
	Selection of personnel and equipment for recovery operations ie other remote controlled equipment and remote control units, experienced and competent production and maintenance personnel. Lack of detail with regards to equipment and personnel during the JSA process.	Ensure the selection of competent personnel and equipment for recovery operations is included as part of a detailed JSA/risk assessment process.
	Two or more remote control sets are used in the recovery operations. The remote control transmitters may have the same frequencies.	Develop a spectrum management system to ensure that no two remote control transmitters have the same frequencies.
	No inspection of the work area undertaken prior to the commencement of the recovery operations.	Develop a process for the inspection and assessment of the work area prior to the commencement of the recovery operations.