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Technical reference guide

Strata support bolting plant in underground coal mines

Safety requirements

(MDG35.1)

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Amendment schedule		
Date	Version	Amendment
January 2024	1	Consultation draft - Replaces MDG35.1 Guideline for bolting and drilling plant in mines Part 1: Bolting plant for strata support in underground coal mines focusing on key areas in design of bolting plant and is a Consultation Draft
May 2024	2	Feedback from consultation incorporated.

Table of Contents

1. Introduction

This technical reference guide (TRG) replaces MDG35.1 Guideline for bolting and drilling plant in mines Part 1: Bolting plant for strata support in underground coal mines. It focuses on key areas in bolting plant design.

The purpose of this TRG is to provide information to help minimise the health and safety risks relating to bolting activities in underground coal mines. This TRG applies to all bolting plant intended to install strata support in underground coal mines. This includes continuous miner bolters, mobile bolters, face bolters for longwall recovery, crawlers, air-track self-propelled bolters, and load haul dump (LHD) powered attachment bolting rigs (QDS / RAS).

This guideline does not apply to portable hand-held bolters.

2. Work health and safety management system

2.1 Work health and safety

The NSW work health and safety laws[1] apply to all workplaces in NSW, including mine and petroleum sites. They impose a general obligation to ensure the health, safety, and welfare of people at work. This is achieved through a framework for identifying hazards, and identifying, assessing, minimising, or eliminating risks.

2.2 Interaction with the safety management system

A bolting plant management plan should be an integral part of a mine's safety management system (SMS) and may form part of a relevant principal hazard management plan (PHMP). For further guidance on safety management systems see:

- NSW code of practice safety management systems in mines
- NSW code of practice electrical engineering control plans (EECP)
- NSW code of practice mechanical engineering control plans (MECP)
- NSW code of practice managing the risks of plant in the workplace
- NSW code of practice strata control for underground coal mines

Underground coal mine operators using bolting plant should develop and implement a plan that provides for its safe system design, operation, and maintenance. This plan forms part of the mine's SMS. The mine operators should development and implement a plan that provides:

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[1] The NSW work health and safety laws consist of the:

Work Health and Safety Act 2011 (WHS Act)

Work Health and Safety Regulation 2017 (WHS Regulation)

Work Health and Safety (Mines and Petroleum Sites) Act 2013 (WHS (MPS) Act)

Work Health and Safety (Mines and Petroleum Sits) Regulation 2014 (WHS (MPS) Regulation)

- controls for managing risks that include safe work systems
- a system for monitoring and verifying the effectiveness of the controls
- fit-for-purpose equipment
- trained and competent operators
- adequate supervision.

The plan should describe the design parameters of the systems. These parameters should not be exceeded or changed without a change-management process, an engineering study, and a hazard identification and risk review process. The plan should clearly communicate this.

Systems, procedures, plans and risk control measures are key elements of a mine's SMS. A mine operator may use a relevant principal hazard management plan (PHMP) to manage bolting plant hazards. Alternatively, they could develop sub-plans, additional control plans, or standards of engineering practice (SEP). The SMS ties all the elements together into an integrated system to effectively manage work health and safety risks to workers. A properly integrated system ensures there are no gaps and that all the elements work in a coordinated way.

All bolting plant should be designed, manufactured, installed, operated, and maintained in accordance with the Part 5 of the Work Health and Safety Regulation 2017 and relevant standards (see Appendix A).

2.3 Consultation

Mine operators should consider the NSW code of practice WHS consultation, cooperation and coordination when managing bolting plant risks.

Mine operators should consult all stakeholders when:

- identifying bolting and drilling system hazards and assessing or reviewing their risks
- making decisions about risk control measures
- introducing or altering the procedures for controlling those risks
- changes, defects, or incidents occur
- developing, implementing and reviewing the mine SMS
- an audit has been completed.

Relevant stakeholders include designers, manufacturers, suppliers, owners, operators (workers), maintainers, supervisors, and the site safety health representatives.

3. Risk management

Mine operators should consider the NSW code of practice managing risks in the workplace when managing bolting plant risks.

3.1 Hazard identification

Designers, manufacturers, importers, suppliers, owners, and mine operators should identify all hazards for every applicable stage of the plant in its lifecycle.

Specific strata support (bolting) and drilling hazards that may lead to personal injury may include, but are not limited to:

- rotating and percussion machinery
- stability of the machine/plant
- mechanical energy
- gravitational energy
- electrical energy
- hydraulic energy
- potential working environment hazards (strata fall, rib, noise, dust, water, strata gases)
- biomechanical energies (poor ergonomics, repetitive work, and manual handling)
- pinch points
- automatic functions
- thermal energy, including frictional ignition of methane, and coal dust explosion
- fire
- excessive noise
- excessive vibration
- excessive atmospheric contaminants, including dust and diesel particulate matter
- poor maintenance practices
- two-person bolting operation (e.g. outbye one person on the controls and the second at the drill mast)
- cable bolting, multiple drill steels and long cable bolts
- component failure
- unplanned movements
- human error factors, especially control selection errors and control direction errors
- inadvertent contact with controls

- inconsistent control layout (e.g. differences between machines and handing from the operator's position)
- operator fatigue
- poor work practices
- change in procedures or the environment
- cumulative musculoskeletal injuries including repetitive strain injury (RSI)
- working at heights
- release of high-pressure fluids
- poor visibility and poor illumination
- congested work area
- slippery and wet environment
- the failure of safety critical components or systems
- strata failure
- inrush.

3.2 Risk assessment

Designers, manufacturers, importers, suppliers, owners, and mine operators must carry out risk assessment(s) on all identified hazards on bolting plant. This ensures appropriate risk controls from the use of bolting plant can be identified. Mine operators must carry out operational risk assessment before using the bolting plant on a mine site.

When using bolting plant, mine operators should review the risk assessments and carry out new operational risk assessments whenever the risk profile changes. For example, where there are variations in design, use, conditions, or the operating environment.

The mine operator's risk assessment should include, but not limited to:

- each location where strata support or drilling activities are being carried out
- site specific hazards, including environmental conditions
- site competencies
- safe work systems before normal operation
- proximity to unstable roof and rib
- the designer's risk assessment and the intended use of the plant
- site/machine specific safe standing zones
- using outbye bolting equipment where 2 operators need to complete the drilling/bolting cycle. (e.g. one operator on the controls and the other operator at the drill mast handling the drills and bolts)

- cable bolting operations
- ergonomics and human and organisational factors
- noise, vibration and heat.

Tools are available to assist in the risk assessment of hazardous manual tasks.

Mine operators should conduct risk assessments and as a minimum:

- address health and safety risks for workers affected by the bolting plant
- address health and safety risks for people near bolting equipment during operation, maintenance, and repair
- identify controls to minimise risks as far as is reasonably practicable and assess the residual risk of any implemented controls
- consider the recommendations of this TRG and other published material to assist in developing safe work systems
- provide for installation being fit for the specified purpose
- determine any additional criteria that may be required for specific circumstances
- develop safe systems of work
- ensure the bolting plant is fit for the specified purpose
- maintenance requirement to ensure the bolting plant is safe to use
- document the instruction and training requirements.

3.2.1 Human and organisational factors

Human and organisational factors are the environmental, organisational, job-related, and human characteristics that influence behaviour at work. These factors can affect health and safety in the workplace.

What people are being asked to do (the task and its characteristics), who is doing it (the individual and their competence) and where they are working (the organisation and its attributes) all influence workplace safety.

While there are many factors that influence the effectiveness of risk controls, mine operators need to consider the foundational human and organisational factors in a workplace safety management system context.

The design risk assessments should consider, through the bolting process maps, the following factors for safe human-plant interaction:

- human failure
- procedures
- training and competence

- staffing and workload
- organisational change
- safety critical communications
- human factors in design
- fatigue and shift work
- organisational culture
- maintenance, inspection, and testing
- emergency management.

3.2.2 Musculoskeletal disorders

Many factors contribute to musculoskeletal disorders (MSD). Designers, manufacturers, importers, suppliers, owners, and mine operators should consider the following risks when assessing the hazards associated with drill plant and strata installation:

- awkward postures
- bending and twisting
- manual handling/load
- forceful exertions
- repetitive actions
- task duration
- heavy lifting
- vibration of hand/arm and whole body (including jolting and jarring)
- poor access to equipment
- slips, trips, and falls
- working long hours without the opportunity for rest and recovery
- exerting force in a static position for extended periods
- problems with the work environment (e.g., working in heat, cold, wet, or other unpredictable conditions)
- high job demands and time pressure
- fatigue
- lack of job rotation.

3.2.3 Noise

Designers, manufacturers, importers, suppliers, owners, and mine operators must take appropriate control measures if exposure to noise at the bolting plant operator's station exceeds:

- an 8-hour equivalent continuous sound pressure level, LAeq,8h, of 85 dB(A), or
- peak levels of 140 dB(C) weighted.

A comprehensive noise survey of the bolting plant should be conducted and be incorporated in the design documentation.

3.3 Risk control

When selecting controls, designers, manufacturers, importers, suppliers, owners, and mine operators should consider:

- having preferably one operator per rig, or per 2 rigs on continuous bolter miners
- when 2 operators are required to operate a single rig the risk assessment should identify all additional controls and procedures required to use the controls. Bolting plant operators should be trained in these procedures. Designers, owners, and mine operators should also consider installing additional emergency stops in proximity to the offsider work area, such as on the mast on an air track/crawler outbye the bolting equipment
- reviewing materials/consumables handling, and storage procedures (consumable pods installed using a QDS jib crane system)
- correct drill steels for bolt installation, bolting horizon, seam height and gradient
- reviewing cable drilling and bolting requirements, and having fit for purpose bolting equipment to minimise manual handling (use a cable bolt pusher and bolt tensioning system)
- safe, appropriate storing of drill steels, dolly, chemicals, mesh, cable bolts, tensioner head, etc to keep them distant from the operation of the drill mast and headplate, and avoid storage on the platforms
- securing butterfly plates/small plates on the headplate (e.g. magnets) to prevent the plates falling
- drilling procedures and training requiring the operator and consumables to be distant from the drill mast when in auto drilling mode
- making platforms flat with non-slip flooring, and the floor illuminated, with access by steps and handrails
- ensuring maintenance at periodic intervals occurs, including checking of slow speed and reduced force when one handed operation is used
- on completion of drilling/bolting the drill motor is to be stored/stopped clear of the floor
- maintenance to include replacing the gripper jaws and/or headplate at periodic intervals

- visual and/or audible alarm when a change of state occurs (e.g., bolting > tramming > cutting). This should include the safe standing zones (or no-go zones) including permission to access the continuous bolter miner
- hydraulic system management.

WARNING: operators need to be aware of an increased risk of injury when interacting with the drill rig, (e.g., placing dolly, drill steel, or bolt installation into drill motor)

4 Design and manufacture

4.1 Information the designer needs

Users of bolting plant should provide to the designer all relevant information about matters relating to the bolting plant that may affect health and safety.

This information should include, but not limited to:

- the intended use including functional, operational and performance requirements
- bolting/drilling/support design parameters (e.g. depths, patterns, and support requirements)
- operational performance (e.g. speed, torque, water flow, etc)
- modes of operation and intended process of bolting
- environmental conditions (e.g. roadway profiles)
- specifications of consumables and storage/handling requirements
- geotechnical report(s) for operator protection systems
- geology and strata information (e.g. identified faults, dykes, and structures)
- any other information requested by the designer for matters that may affect health and safety.

4.2 General design requirements

The designer should follow credible engineering principles. All bolting plant should be designed, manufactured, constructed, and tested using engineering principles to ensure the bolting plant is fit for the specified purpose and can operate safely over the intended design lifecycle of the system.

Note: Part 5 of the WHS Regulation 2017 stipulates specific requirements for the design and manufacture of plant.

Bolting plant design should allow reasonable access to all parts that require adjustment, cleaning, or service. All routine maintenance and servicing actions should have appropriate isolation and should be possible without the removal of fixed guards, where practicable.

Bolting plant design should avoid sharp edges on the plant that could injure people (ISO 12580) along with any pinch point areas where operators may work or stand during normal operation.

Designers should make provisions to secure all loads associated with the bolting and drilling activities, such as securing materials and consumables storage to prevent shifting during operation and flitting.

Bolting plant designs should include a system for the safe handling and loading of consumable materials (e.g., drills, bolts, chemicals, plates, cable bolts, mesh etc.). The handling system should, where practicable, minimise reach distance and exposure to hazards. The designer should consult the end users (owner, mine operator, workers, etc) about specific site requirements to design and develop this handling system.

Bolting plant handling system design should include both positioning of consumables on the bolting plant and moving consumables from the bolting plant to the drill rig area.

The designer should identify hazards to worker health and safety from the bolting and drilling process (e.g. air exhaust, dust etc.) and should minimise the operator's exposure as far as reasonably practicable. Positioning of bolting equipment and consumables should not affect or restrict the operation of onboard ventilation systems.

Designers should consider safe lift points for plant and/or major components that could cause a hazard to operators. Lifting points should be clearly marked.

Designers should consider when designs include cable bolt systems the mechanical feeding of the cable bolt into the drilled hole and tensioning requirements.

4.3 Ergonomics

The designer should consider the safety-related aspects of ergonomic issues when addressing the layout of all bolting plant components and their use for operators carrying out:

- repetitive work
- maintenance work.

The designer should carry out an ergonomic assessment on the layout of all operator controls. A suitably competent person should carry out an assessment in consultation with the end users.

4.4 Guarding of moving and rotating parts

The designer of safeguarding systems should consider the AS4024 suite of Standards. The designer should ensure safeguarding systems are designed to make bypassing or defeating (whether deliberate or by accident) as difficult as is reasonably possible and provide minimal interference with operational functions to reduce any incentive to defeat them.

The designer should provide an effective safeguarding system to prevent access to all danger points or areas on the bolting plant where people may become injured by interaction with moving parts, rotating parts, nip/shear points and contact with hot surfaces. The required outcome is reducing the risk to as low as reasonably practicable.

The designer should consider safeguarding means/systems that may include, but are not limited to:

- physical guards (e.g. interlocking if guard needs to be regularly removed for operational reasons)
- bolter component operation speed (slow speed)
- two-handed operation
- sensitive protective devices (e.g. presence devices, pressure mats, etc.)
- controlled or reduced force (thrust or rotation)
- pinch point preventers (e.g. buffers, spacer stops, or bump stops)

Note: The devices above assist in preventing crush injury between the head plate and feed frame, deflectors from pinch/shear points, and other forms of protective devices.

The designer should ensure the required level of safeguarding systems should be appropriate to the level of risk for the function as determined by the design risk assessment.

Note: A combination of guards and protective devices may be required to achieve the required level of protection.

Fixed rigid guards on moving parts should not create an additional nip or shear hazard.

Designers should use relevant Standards (e.g. ISO 13851) where two-handed operation is required.

The above safeguarding systems (principles) should use push button and remote-control bolting operation.

4.5 Bolting function

4.5.1 Bolting rig operation

The designer, manufacturer, importer, or supplier should provide a series of bolting process map(s) or sequence(s). These documents define the designed bolting rig operation process, including the operator protection system. This should cover the entire bolting cycle. The map or sequence document should be developed in consultation with the end user.

The design risk assessment should identify the hazards and assess the risks at each stage. The process map should identify the risk controls for each stage in the process.

Note:The process map will be specific to the equipment supplied to the mine and the mines specific requirements. Appendix C includes a typical bolting process map example.

4.5.2 Single person operation

The designer should design each individual bolting rig for single person operation.

Note: There are additional risks when 2 or more people are required to operate or interact with the same bolting rig. Rib bolters require more direct interaction.

Where single person operation is not practicable a risk assessment should identify:

- the required operators position

- the number of operators
- the additional hazards and required risk controls.

4.5.3 Drill motors

The chuck of a drill motor should have a smooth surface, with no catch points, to minimise the risk of injury if an operator accidentally touches the chuck.

The design should reduce the number of interactions between the operator and the drill motor. The design should enable the operator to use a chuck that suits both drilling and bolting functions without using a bolt tightening device (dolly) where practicable.

The designer should provide a means of securing both the rotating drilling steel and the bolt tightening device (dolly) in the drill head. This allows the operator to drill holes and install bolts without stabilising a drill/bolt with their hand.

Note: Injuries have occurred from operator interaction with moving components of the drill rig.

4.5.4 Gas ignition prevention

Designers, where there is a risk of gas/frictional ignition with wet drilling in automatic mode, should provide water flow monitoring or other monitoring techniques on each drill rig. The water flow monitoring should stop the drilling function when the water flow and/or pressure are insufficient to prevent a blocked drill.

Note: Undetected blocked drills have caused a fire or gas ignition previously.

Designers of electro-hydraulic bolting rig systems (including remote or other techniques) should consider monitoring techniques that may be available to detect blocked drill steels to prevent gas ignition.

4.5.5 Drill guides

The designer should incorporate a system of guiding the drill steel (e.g. head plates). The operator may use bolting washers or gripper jaws to guide the drill steel. Head plates should positively retain the roof bolt plate or butterfly during the bolting and drilling functions. The designer may incorporate drill guides in the rig head plate or use other techniques.

Note: Manually operated mechanical drill guides should not be used unless otherwise safe guarded. Operators have been injured due to pinch points on manually operated drill guides.

4.5.6 Gripper jaws

The designer should include gripper jaws to hold the drill steel or cable bolt in the head plate where the operator uses extension drills, and cable bolts.

The designer should provide a load holding device on the gripper jaw function to prevent the drill/bolt falling.

Note: The function of the load holding device is to prevent the drill/bolt from falling if there is a power failure or oil dissipation away from the gripper jaw cylinder load holding valve.

4.5.7 Drill steels

The designer and end user should consult to ensure drill steels are compatible to feed pressure (single hand operation) to prevent the drill steel bending. This depends on the length, material, and shape of the drill steel.

The designer should provide a safe means of removing a jammed drill steel from the strata.

Note: The use of gripper jaws as a safe means is recommended.

4.5.8 Cable bolts

The designer should consider the requirement for the drill rig to be capable of installing cable bolts, including but not limited to:

- the drill steel and requirements to hold and connect the drill steels
- a device to install the specified cable bolt into the roof strata.

A system in use is a cable bolt pusher head plate that pushes/drives the cable bolt up into the drilled hole. The mine may require a cable bolting system that enables the cable bolt to be torqued to a higher tension. A system should be in place to torque the bolts to the correct tension.

The designer should ensure all equipment is fit for purpose.

4.6 Drilling and bolting machine controls

4.6.1 General

Designers of the primary bolting controls, secondary controls and ancillary controls should minimise the risks to health and safety.

The designer should consider risks associated with bolting controls including but not limited to:

- entrapment/entanglement during operation or maintenance activities
- an operator incorrectly selecting controls
- inadvertent or accidental operation
- maintenance people incorrectly adjusting the controls
- incorrect functionality (e.g. layout of controls, orientation inconsistent with direction of movement
- incorrect movement – up and down, in and out (from non-standardisation of controls between different manufacturers)
- the operator being caught due to unsafe speed of operation
- cumulative and/or repetitive loading being applied to parts of people's bodies.

The designer should protect the bolting controls to prevent accidental contact by external objects such as operator or falling material (e.g. roof or rib).

The designer should design the bolting controls that are identified as safety critical controls with the appropriate integrity level.

Where the failure of solenoid or pilot operated control valves increases the risk to safety, spools should be monitored, where practicable. The designer should position the bolting controls so that the operator stays under permanently supported roof or under an operator protection system.

The designer should install an operator rib protection when there is a rib failure hazard. The rib protection should protect the operator when a rib fails. The structural strength of the rib protection depends on the mine's conditions.

Note: Fatalities and serious injuries have occurred from rib failures.

The designer should include bolting controls at each operator's workstation and within the operators reach envelope. When this approach is not practicable, a risk assessment should determine alternative risk controls (e.g. rapid face bolters, longwall face bolters, and outbye bolting equipment, air tracks, crawler/mobile bolting rigs and QDS drill rigs).

See Appendix A for definition of 'stop' controls.

4.6.2 Emergency stop and/or machine stop controls

The designer should provide emergency and/or machine stop facilities following relevant Standards and these should:

- be designed with the appropriate integrity level
- be prominent, clearly, and durably marked (e.g. a large RED handle/bar/push button)
- have emergency stop buttons that should have a yellow background to clearly identify it as an emergency stop, not a machine stop
- not be affected by electrical or electronic circuit malfunction
- shut down all power in a time as short as reasonably practicable
- remain in the off position until manually reset.

The resetting of emergency stop devices should not cause the bolting plant, bolting rig, or associated plant to operate.

Clause 191 of the WHS Regulation 2017 imposes obligations on the plant designer regarding emergency stop controls.

4.6.3 Emergency stop and/or machine stop control location

Designs as a minimum should have emergency and/or machine stop controls located at:

- each tramming station, and

- within reach of each bolting rig control station.

Designs, when electrically powered machinery is to be used should have an emergency stop on the main electrical enclosure that drops power from the supply point.

The location of the emergency stop device should be readily accessible to the operator during normal operation.

The location of the emergency stop device should not place the operator or any part of their body within any danger zone.

Note: Where there are two or more operators operating the same bolting rig each operator should have access to an emergency stop.

4.6.4 Hydraulic stop (Bolting rig stop)

The designer should consider an individual bolting rig stop at the bolting rig operator's workstation.

When fitted, this device should stop and interrupt hydraulic energy to the bolting rig controls and should stop all bolting and drilling functions for that bolting rig.

The hydraulic stop valve should latch, require manual reset, and not restart functions when manually released.

Note: The designer should consult the end user to enable the drill rig to comply with site specific isolation procedures. A bolting rig stop is a machine stop. The bolting rig stop is not an isolation point or an emergency stop.

4.6.5 Bolting rig isolation valves

An operator may use individual hydraulic stop/isolation valves to remove hydraulic power to the drill rig controls.

Note: The designer should consult the end user to enable the drill rig to comply with site specific isolation procedures. Most drill rig installations do not have bolting rig isolation but use full machine isolation and lockout as per the mine's isolation procedure. Full machine isolation is the best practice.

Designs where drill rig isolation is provided should comply with the mechanical engineering control plan and the mine's isolation procedures.

Designers, where hydraulic isolation valves are used to remove hydraulic power to bolting rig controls, should conduct a risk assessment in conjunction with the end users to determine the level of isolation required for work activities. The hydraulic isolation valves should:

- be on the supply side of the hydraulic circuit to each work area (e.g., a single bolter or several bolters)
- be located at the control station or near the operator
- have individual hydraulic isolation valves that are lockable
- be readily accessible and user friendly

- be clearly identified (labelled)
- be easily distinguishable from an emergency stop
- have a means to test the valve is closed, and test the controls are not functional.

Note: Other functions on the drill rig/associated equipment should be isolated if there is any interaction of other components (shovel, boom, and other rigs etc). This area should be included in the risk assessments. Best practice is to use full isolation and lockout when working on bolting plant.

4.6.6 Manual controls

The designer should ensure the choice of manual controls is appropriate for the operation being initiated (e.g., a push button used for on/off controls, levers for proportional controls, etc.). All manual controls required by automatic, semi-automatic or gripper jaw functions should automatically return to the neutral position when released by the operator.

The neutral position on manual controls should be easy to find.

The neutral position on a manual control valve should not hold stored pressure on the actuator side of the valve to prevent unintended movement. Pressure should divert back to tank or exhaust, unless required by the plant function (e.g., gripper jaws).

If any function has more than one manual control station, the designer should provide effective protection or interlocking to control the dual operation risk.

4.6.7 Direction of operation

The designer should ensure the direction of operation of manual controls should be consistent with the direction and response/movement of the actuator or the plant, where practicable. Refer to Table 1.

Designers should use an upward movement of a horizontal control to cause extension where horizontal levers are used to control the extension of a timber jack to either the roof or rib.

Designers should use an upward movement of a horizontal lever to cause feed where horizontal levers are used to control drill feed to the roof or rib.

Designers should use movement of the vertical lever away from the operator to cause extension where vertical levers are used to control extension of a timber jack to roof or rib.

Designers should use movement of the vertical lever away from the operator to cause feed where vertical levers are used to control drill feed.

Note: AS 4024:1906 provides guidance on general principles. Group 1 is preferable.

Table 1: Classification of control actions- Group 1 (AS/NZS4024.1906)

Nature of Actuator	Nature of Action	Direction of Action
Handwheel, handle, etc	Rotation clockwise	Clockwise ↷
	Rotation anti-clockwise	Anti-clockwise ↶
	Vertical motion upwards	Upwards ↑
	Vertical motion downwards	Downwards ↓
Grip, lever, push-pull button, etc. with essentially linear motion	Horizontal motion right	To the right →
	Horizontal motion left	To the left ←
	Horizontal motion forward	Away from the operator ⊗
	Horizontal motion backward	Towards the operator ⊙

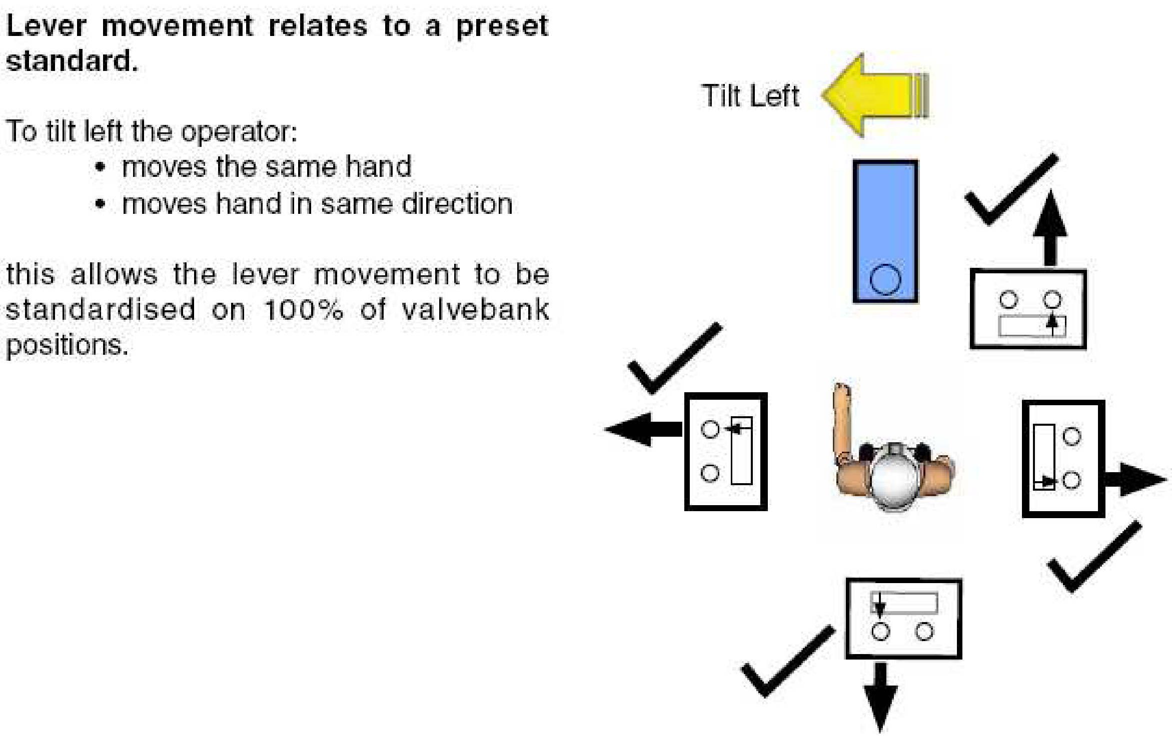
4.6.8 Manual control locations

Designers should position manual controls, so they are:

- located within the operators reach envelopes at each tramming, bolting and ancillary workstation, where practicable. Further guidance can be found in AS/NZS 4024.1903
- in similar locations for similar types of plants, to assist operators who may regularly operate different plants
- arranged so that the controls are handed identically, irrespective of the location on the bolting plant, where practicable. e.g., the right-hand lever should operate the same function on both sides of the bolting plant (see Figure 1).

Note: It may not be practicable for some functions to be handed identically (e.g., where the control needs to be within reach of the drill). Different manufacturers may have different locations for the same function. This may create a hazard to operators where different manufacturer's bolting rigs are in the same workplace.

Figure 1: Manual control positioning



4.6.9 Two-handed operation

Designs where two-handed operations are used it should comply with AS/NZS 4024:2601.

The designer should prevent operators defeating the two-handed control features as far as reasonably practicable. The designer should also consider reasonably foreseeable misuse.

Note: Two handed manual controls only protect the operator. They may not protect others in the vicinity of the bolting rig.

4.6.10 One-handed operation

Designers of one-handed operation of primary and secondary controls should limit all drilling and bolting functions to a safe speed of operation. The one-handed operation should also reduce the force of the thrust to prevent drill steels bending.

4.6.11 Modes of operation

The design risk assessment should determine the modes of operation for the mobile bolting plant and isolation requirements. Modes include:

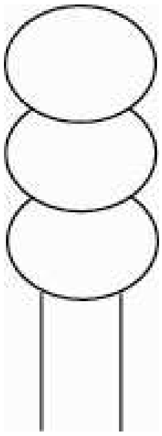
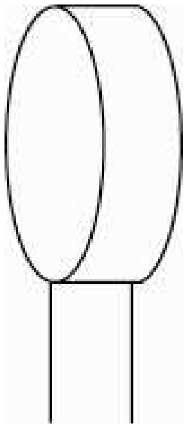
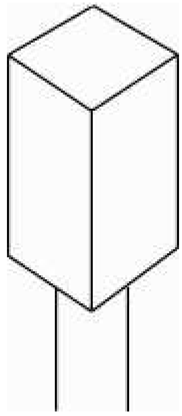
- a bolting mode to allow all bolting functions
- a maintenance mode for carrying out maintenance or servicing functions
- a tramming mode to allow the bolting plant to move forward/reverse, turn, stop, and brake if required.

4.6.12 Control recognition

The designer should clearly distinguish primary bolting controls from other primary controls and secondary controls. This is to establish their significance. For example, controls extended slightly beyond each other, separated (positioned), etc.

Handles (levers) used for primary bolting controls should use the shapes in Figure 2 to assist with control recognition.

Figure 2: Primary bolting control shapes

Rotation handle	Feed handle	Timberjack handle
		
Rotation knob handle (three balls)	Feed knob handle (flat disk)	Timberjack knob handle (rectangle)

Note: Operators inadvertently operating the wrong control have caused incidents previously. If a joystick control is used to control two separate functions, i.e., rotation and feed, use the three balls in a line (rotation shape).

4.6.13 Drill rotation and drill feed controls

Designers should ensure drill rotation and drill feed manual controls cannot be operated by one hand unless there is a safeguarding system to protect the operator(s).

Note: The intention is to prevent single handed operation for drill feed and rotation. Accidents have occurred due to operators using their free hand while drilling and subsequently becoming entangled. Use AS/NZS 4024:2601 as a reference for two handed control and control separation distances. For the rotation control, two action operation should be used in conjunction with an ergonomic assessment, e.g., lift and push/pull to operate the function.

4.6.14 Automatic operation

For designs that initiate either automatic or semi-automatic functions a safeguarding system should be provided so the operator is clear of rotating or moving parts. This may include two separate controls activated in an order. Where provided, these controls should be segregated so they cannot be operated simultaneously by one hand.

Note: See AS/NZS 4024:2601 for control separation distances.

If energy to a bolting rig is removed and then later restored (while operating in automatic or semi-automatic mode), the automatic / semi-automatic function should be disabled, the bolting rig should not move, and the controls should return to the neutral position. The operator must manually reset operation of the automatic or semi-automatic function when energy is restored.

When the automatic cycle is completed, it should disable, or return to neutral, the manually operated automatic select mode. The drill rig should not move again until it is manually reactivated by the operator.

Note: The intention is to prevent the automatic function operating on more than one cycle. The designer should consider varying the stop position of the drill motor on the return cycle. The designer should consider keeping the drill steel positively engaged in the drill motor chuck as it is retracted from the roof.

4.6.15 Safe speed of operation

When a safe speed of operation is used as a risk control (e.g., one handed operation), it should be at an operating speed such that an operator can recognise and avoid a potential hazard.

A risk assessment and testing should determine the safe speed of operation as applied to each function and application.

The designer should ensure the controls for setting safe speed of operation are not readily adjustable.

Note: The safe speed may be different between functions, (e.g., drill feed and tilt) and may also be different between different bolting plant (e.g., miner bolter, mobile bolter). The designer should consider human reaction times in avoiding hazards when determining the safe speed of operation. Safe speed of operation as a single risk control may not be suitable for high consequence risks.

4.6.16 Drill feed

When positioning the drill steel with manual control, the bolting rig control system should limit the force (pressure) of the drill feed actuator to minimise the potential for bending of the drill steel. The operator should not be able to readily adjust this force.

When drilling, the operator should be able to use a system that automatically assists in preventing the drill steel bending and/or blocking.

The operator should be able to alter the drill feed force and speed to adjust for the different strata conditions or for when cable bolting.

Note: The drill steel positioning force will be different from the drilling force. Best practice is to have feedback from the drill motor torque to reduce feed force while drilling.

4.6.17 Rib bolters – additional requirements

Rib bolters should have the capability to tilt left / right to allow proper alignment of rib bolts with drilled holes. This will accommodate movement of the plant and misalignment.

When the rib bolter is in the parked position the extension (timber jack) function should be disabled.

Note: Injuries have occurred due to inadvertent operation of the rib bolter extension (timber jack) function. Extra slow final positioning of the rib bolter may assist.

4.6.18 Labelling of primary bolting controls

The designer should label the handles of primary bolting controls on bolting rigs according to Table 2 below.

Table 2: Labelling of primary bolting controls

Bolting function	Label of control
Rotation control	Forward/reverse (clockwise/anticlockwise)
Feed control	Advance/retract
Timber jack control	Extend/retract

Note: The designer may provide a graphic symbol on the name plate for further clarification.

4.6.19 Labelling for secondary controls

The designer should label secondary controls on bolting rigs according to Table 3 below.

Table 3: Labelling of secondary controls

Positioning function	Label of control
Tilt control	Left/right Forward/back
Traverse control	Left/right
Rig raise control	Raise/lower
Rib slide control	Extend/retract
Slew control	Forward/back Left/right
Side shift	Left/right

Note: The designer may provide a graphic symbol on the name plate for further clarification.

4.6.20 Push button controls – remote controls

The designer should ensure the push button/remote controls comply with the following principles.

Designs for two-handed controls when using the primary bolting function:

- will distinguish the primary bolting functions (rotation, feed and timberjack operation) to be distinguishable by sight and feel, i.e., a raised / indented section around the primary buttons. The intent is to prevent inadvertent operation of controls could use shrouding, tactile buttons colours on buttons showing function
- will reduce operator interaction with the bolting rig during operation
- will protect the operator. They may not protect others in the vicinity of the bolting rig
- should not allow drill rotation and drill feed button, or remote controls to be operated using one hand
- will prevent single handed operation for drill feed and rotation

Note: Accidents have occurred due to operators using their free hand while drilling and subsequently becoming entangled

- two action operation should be used in conjunction with an ergonomic assessment for the rotation control (e.g., lift and push/pull to operate the function)
- the designer should ensure the operator is provided with a safeguarding system to initiate either automatic, or semi-automatic functions, so the operator is clear of rotating or moving parts. This system may include two separate controls buttons activated in a particular order. Where provided, the system should segregate these controls so the operator cannot operate them simultaneously using one hand.

Designs for one hand control should have additional controls in place:

- for slow speed of operation. An operating speed such that an operator can recognise and avoid a potential hazard.
- to reduce thrust force when positioning a drill steel.

When using automatic operations, the drill motor should return to the park position when automatic operation is complete.

4.7 Operator protection systems

4.7.1 General

Mine operators in managing the risks to the health and safety of operators must comply with the requirements of section 55 of the WHS(MPS) Regulation 2022 regarding unsupported ground or strata.

The mine operator should provide an effective system to prevent injuries to operators from material falling from either the roof or ribs.

The operator should be able to carry out the strata support process from under:

- permanently supported roof and supported rib, and /or
- an operator protection system which provides an appropriate level of protection.

The system should protect the operator from mobile bolting plant travelling risks (e.g., overturning, or the operator hitting fixed objects).

Designers and end users should consider the typical strata operator protections systems in Table 4.

Table 4: Typical operator protection systems

Typical risk	Typical operator protection systems
A massive failure of the roof causing fatal or serious injury.	• people working under supported roof in accordance with the mine ground or strata failure principal hazard management plan
A skin failure of the roof causing fatal or serious injury.	• people working under supported roof in accordance with the mine ground or strata failure principal hazard management plan • people working under the influence of a TRS to install permanent roof support • people working under the influence of a protective canopy. **Note:** May be suitable for outbye areas of the mine to clean up roof falls
A skin failure of the roof causing a minor injury to the operator.	• people working under supported roof in accordance with the mine ground or strata failure principal hazard management plan • people working under the influence of a TRS to install permanent roof support • mesh • operator protective guard • protective canopy • flippers on timber jacks • safe standing zones • use of gloves.
A massive failure of the rib causing fatal or serious injury.	• people working under supported rib in accordance with the mine ground or strata failure principal hazard management plan • people working under the influence of a rib protection shield designed for the expected loading.
A skin failure of the rib causing fatal or serious injury.	• people working under supported rib in accordance with the mine ground or strata failure principal hazard management plan • people working under the influence of a rib protection shield.
A skin failure of the rib causing a minor injury to the operator.	• people working under supported rib in accordance with the mine ground or strata failure principal hazard management plan

Typical risk	Typical operator protection systems
	• people working under the influence of a rib protection shield • ergonomic design to prevent people being in risk areas • mesh • no standing zones • handrails • use of gloves.

4.7.2 Design and loading criterion for operator protective structures

When used as a risk control, operator protective structures should be designed to the geological and strata loading conditions as specified by a geotechnical engineer or the mine's ground or strata failure principal hazard management plan.

A competent mechanical or structural engineer should design the operator protective structures to the relevant standards.

The geotechnical engineer or the ground or strata failure principal hazard management plan should:

- as the mine's strata conditions change, require reassessment of the bolting equipment to retain fit for purpose bolting equipment to suit any such change in condition
- state the maximum loading conditions for any TRS, rib protection shield, or protective guard, as required
- fully document the determined loading conditions, and fully state any assumptions made in a manner that is auditable
- state the required set load for and minimum footprint for any TRS or rib protective structure
- state any conditions or assumptions made in calculating the loading conditions
- state the geological and geographical area limitations of the geotechnical information provided.

Note: If the operator protective structure is designed from geotechnical information from a particular mine or mines, mining method, or mining seam, that structure may be inadequate for other mines, mining methods or mining seams.

4.7.3 Temporary roof support (TRS)

Designs that use TRS systems as a risk control, should be designed to:

- consist of pads or crossbars (see Figures 1 and 2 below) which support the roof in advance of the last line of permanent supported roof prior to the strata support cycle and as near as practicable to the bolting rig

Note: Controls that prevent the potential for material to slide or cantilever onto the operator may be useful.

- support the roof above the operator's work area
- ensure the operators work area is not located beyond the last line of permanently supported roof, unless supported by sufficient TRS as specified by the mines ground or strata failure principal hazard management plan or geotechnical engineer
- support, within the elastic range of the structure, the minimum rated design load the geotechnical engineer specifies as the load rating for the TRS, or as it is specified in the mines Ground or strata failure Principal hazard management plans

Note: A TRS is not designed to support the entire weight of the roof but is designed for load stability and to temporarily support the local area until permanent support is installed.

- incorporate a device capable of withstanding the rated design load of the TRS (e.g., a load lock, that will stop movement in the event of a failure of a hose or pipe)
- have a yield system to progressively lower the TRS if the rated design load is exceeded and before any plastic deformation of the TRS structure occurs
- be capable of withstanding the axial and side loading associated with any angle of inclination of the TRS
- after the TRS is set, allow the operator to carry out the strata support process without any further adjustments to the TRS. The TRS remains in place during the strata support cycle until the roof bolt(s) have been securely anchored
- have a bearing pressure (set pressure/set force) consistent with the nature of the roof such that it does not break up the immediate roof when the support is set and/or lowered
  - This requires the set pressure to be able to be varied for changing strata conditions
  - The actual pressure to be applied will vary depending upon prevailing strata conditions and should be managed by the mine’s ground or strata failure principal hazard management plan and/or geotechnical engineer
  - It is preferable to design a TRS with a larger support pad (footprint) to minimise the bearing stress on the strata
- be mounted on a support structure suitable for the load
- prevent tramming of the bolting plant when the TRS is set to the roof

- not use a roof bolter timber jack for part of a TRS system unless it is specifically designed for that function
- have its positioning and setting controls operated from under permanently supported roof or other operator protection system which provides an equivalent level of safety
- prevent injury to the operator, in conjunction with other systems, from small brat (small pieces of roof) that may fall
- be labelled with its rated design load and yield capacity
- have suitably identified and labelled controls that are protected from accidental or inadvertent operation
- be fitted with an emergency stop, machine stop, or hydraulic stop located near the TRS controls.

Figure 3: Crossbar type TRS (preferable)

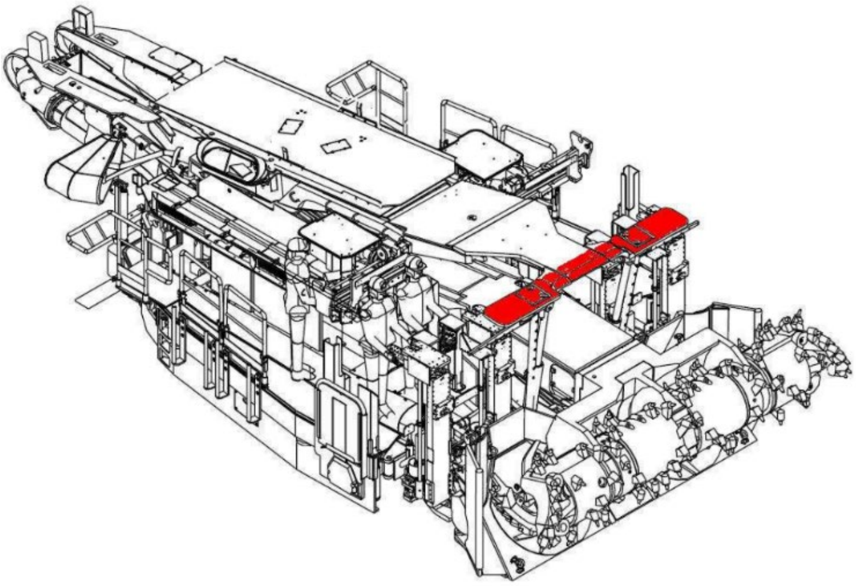
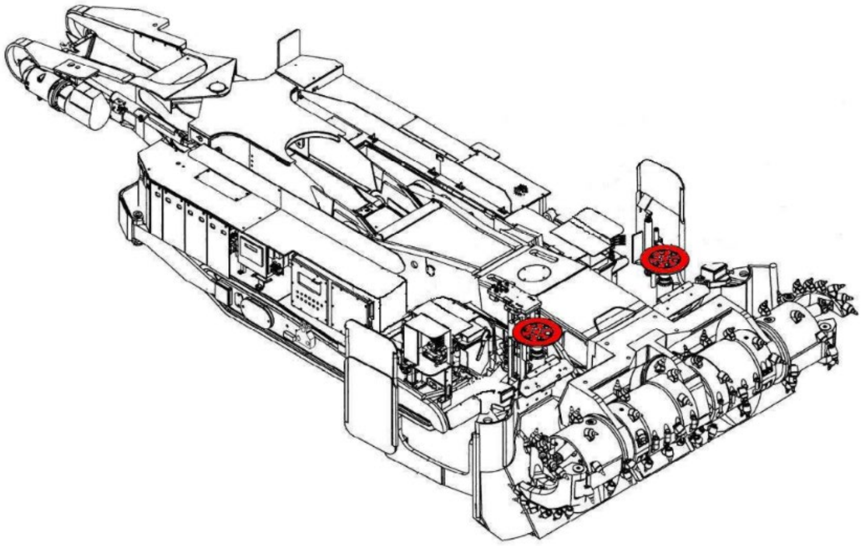


Figure 4: Pad type TRS



4.7.4 Rib protection shield

The designer should install operator rib protection where a rib failure hazard exists. The rib protection should be designed to protect the operator when a rib failure occurs. The structural strength of the rib protection is dependent on the mine's conditions. Rib failures can cause fatalities and serious injuries.

Designs when rib protection is used as a risk control should have rib protection shields as follows:

- provide rib fall protection that limits / deflects rib failure to protect the operator
- protect the operator from the rib strata in the work area. The rib hazard will be different from mine to mine as a result of different geological issues
- have controls which are operated from a safe position under permanently supported roof, and supported rib
- protect operators during the operation of the rib shield movement (e.g., slow speed, required force, pinch points etc)
- have suitably identified and labelled controls that are protected from accidental or inadvertent operation
- are fitted with an emergency stop located near the rib shield control system.

4.7.5 Operator protective guard

Designs for operator protective guards used as a risk control should prevent small, falling material hitting and injuring the operator during or from the strata support process. Mesh modules, TRS, protective guards and secure strata may provide adequate protection.

4.7.6 Operator protective canopy

Designers of protective canopies used as a risk control should ensure they:

- are capable of protecting the operator from a fall of the roof strata in the area of work
- are capable of supporting the mass loading of the roof strata in the area of work
- comply with Gazettal Notice: Government Gazette No 420 of Friday 9 September 2022 Canopies on continuous miners (nsw.gov.au)
- comply with MDG 17 Construction of continuous miners Appendix 1 dated 5th January, 1989

4.7.7 Operator protection platform on bolting plant

The designer should ensure the platforms of bolting plant, and person baskets used for bolting, have an appropriate operator protection system to address risks. The designer should ensure a uniformly level platform without any trip hazards that also provides proper access and handrails.

4.7.8 Documentation and labelling

The designer should document all operator protective systems specifying their design load rating and include them in the plant safety file.

The designer should label all operator protection structures to identify the design loading criteria.

4.8 Dry bolting

Before designing dry bolting systems, the design risk assessment should identify, assess, and control any additional risks to that of wet bolting.

Some factors include, but are not limited to:

- dust levels/exposure
- dust disposal
- noise levels
- temperature
- frictional ignition
- gas
- sparking from a static charge (static electricity)
- ventilation
- compressed air and air discharge

Dry bolting systems should be fitted with a mechanical dust extraction system to prevent dust accumulating in the operator’s work area. The dust extraction system should be located as close as practicable to the source of the dust generation.

The dust extraction system should comply with AS/NZS 4024:1302 where applicable.

The dust extraction system should enable periodic inspection and testing. The system should direct contaminated exhaust air away from any operator.

4.9 Fluid power

Designs using fluid power systems should be designed using Technical Reference Guide for fluid power system safety requirements (MDG 41) and AS 2671.

The designer of the bolting rig and controls should minimise external hoses by using internal porting and or electro hydraulics system.

The designer should use fixed guarding on external hoses to protect the operator, for example hoses connecting to the drill motor.

4.10 Bolting plant

4.10.1 Surface temperature

Surface temperature on any part of the bolting plant must not exceed 150 Degrees Celsius (150°C).

4.10.2 Access to bolting plant

All bolting plant should have stable and secure work areas.

Operator platforms should be designed to AS 1657. Where there is a risk of a worker falling from heights then the design risk assessment should stipulate appropriate controls.

Access and egress to bolting plant should have three-points of contact.

Elevated work platforms should align with AS 1418.10 as far as reasonably practicable.

Landing areas should be designed with a non-slip surface that is easy to clean.

4.10.3 Reflectors and lights

The designer should provide adequate reflective media at each end, sides, and extremities of the bolting and drilling plant. The designer should provide adequate illumination for the bolting work area to enable the operator to work safely.

The following should be considered:

- recognition of operation of controls
- movement around the work area
- interaction points with the bolting rigs
- changes from dark to light areas.

4.10.4 Pre-start warning device

The system should activate an automatic audible and/or visual warning device on:

- on initiation of traction movement
- on a change in traction direction, or
- when bolting and drilling mode is selected.

Designers selecting the type of warning (i.e., visual and/or audible), should consider the work environment and personal protective equipment normally in use, (i.e., hearing protection).

The warning should last for a suitable period of time before the movement commences such that an operator has sufficient time to become aware of the operation.

4.10.5 Brakes

The designer should provide brakes on all mobile plant using the relevant requirements.

The designer of self-propelled bolting plant should fit a failsafe brake system which is spring applied (fail to safe).

Brakes should be totally enclosed, liquid cooled and limit exposed surface temperatures to a maximum of 150 degrees Celsius (150°C).

Where bolting plant is self-propelled and carries people refer to the Mine Transport Design Order 2022 Registration of braking systems on plant used in underground coal.

See Appendix B for relevant TRGs for approval of transport braking systems.

4.10.6 Stability

The designer should specify the maximum operating and transport grade of the bolting plant for its safe operation.

The designer/manufacturer/importer/supplier should clearly define stability grades in documents (tipping forward, backward and sideways).

Outbeg air track or crawler track bolting equipment may require the mast and boom to be in the parked position. The designer may fit parked position sensor(s) with an interlock switch to allow tramming.

4.10.7 Tramming

The designer should use manual tramming controls positioned to keep operators clear of the path of the plant unless the movement of the plant is at a speed sufficiently slow enough and will not create a risk to health and safety.

The designer should:

a) locate tramming controls to minimise the potential of injury from movement of the plant or strata
b) interlock the tramming control circuit to prevent simultaneous drilling while tramming
c) locate hoses and/or cables to prevent an operator from tripping while tramming
d) specify the safe standing zones or operator location while tramming the plant[2].

Machine anchor points should be provided for the attachments of cables and hoses as required.

[2] Refer to AS/NZS4240.3 Remote control systems for mining equipment Operation and maintenance for underground coal mining.

4.10.8 Remote controls

Designers should ensure all remote operated bolting plant use the following standards:

- AS/NZS 4240.1, Remote control systems for mining equipment design, construction, testing, installation, and commissioning.
- AS/NZS 4240.3, Remote control systems for mining equipment operation and maintenance for underground coal mining.

4.10.9 Couplings

Designers should use connections between pumps and motors that are flange mounted to reduce the possibility of fire from misaligned flexible couplings.

4.10.10 Material

The designer where practicable should use non-flammable and antistatic materials to construct the bolting and drilling plant.

Designers should consider hazards such as, toxic fumes, flame propagation and static discharge.

4.10.11 Signs, labels, and warning notices

The designer should follow relevant standards to design all signs, labels and warning notices. They should be:

- of durable, and corrosion resistant construction
- permanently attached, and
- positioned so they are clearly visible.

The designer should label items including, but not limited to:

- manual controls
- isolation points
- emergency stops
- machine stops
- hydraulic stops
- mechanical safety stops (mechanical load holding device locations)
- safeguarding systems
- bolting and drill rig functions
- tare and gross weight of the bolting or drill rig
- plant stability warnings including conditions where items are in fully extended position
- warning on accumulators to release pressure before maintenance work commences

- warning signs to stand clear of and identify any pinch points (e.g. stab jack)
- requirement to wear appropriate PPE
- identification of protective structures.

4.11 Design documentation

4.11.1 General

The designer should fully document the design of the bolting and drilling plant for the As Built system.

The designer should update documents, including the plant safety file, as soon as practicable when there are alterations to the system, and distribute details. The designer should ensure incorrect information won't create new hazards.

The Owner and/or Mine Operator should have and maintain the design documentation in a plant design safety file, including:

- specification of plant
- system design parameters and limitations
- circuit and schematic diagrams
- installation testing and commissioning data
- operation and lifecycle maintenance requirements.

4.11.2 Specification of plant

The designer, manufacturer, importer and/or supplier should provide the Owner and/or Mine Operator of bolting plant a documented specification of the plant including, but not limited to:

- system operating limits and capacities
- general arrangement drawings showing the physical dimensions of the plant
- details of safety critical systems
- hydraulic and pneumatic circuit diagrams
- electrical schematic
- schematic and logic drawings of power and electrical control facilities
- detailed parts lists of all components including reorder codes
- transport and lifting requirements

4.11.3 System design parameters

The designer should document system design requirements including, but not limited to:

- the purpose and intended operations of the bolting and drilling plant

- intended service lifecycle of the system and its components
- design parameters and assumptions made
- operating duty / cycle of the system and its components
- functional specifications, operating parameters, and control logic for the system
- operating environment
- safety related information from manufacturers design and engineering risk assessment
- identification of safety critical systems.

4.11.4 Installation testing and commissioning data

The designer/manufacturer/importer/supplier should provide installation, testing and commissioning procedures including but not limited to:

- identification of hazards, appropriate controls and control verifications
- safe work procedures associated with the installation, testing, and dismantling of the bolting and drilling plant
- testing, inspection and commissioning requirements and documentation.

4.11.5 Operation and lifecycle maintenance requirements

The designer/manufacturer/importer/supplier should provide operation and maintenance manuals. These manuals should have the following information categorised in appropriate sections:

- any specific competencies required to operate, maintain, or repair the plant
- list of the safety critical systems of the plant
- process mapping for the complete drilling and bolting cycle, including the setting of the TRS, installation of rib bolts and provision of supplies as applicable
- recommended preventative maintenance requirements to maintain the bolting and drilling plant in a safe operating condition
- recommended examinations, inspections, and tests, to verify the plant is fit for purpose and safe to operate when properly used
- identification of any hazards involved in maintaining and operating the plant
- provide recommended operating, training and maintenance information for the full life cycle of the strata bolting equipment
- energy isolation, dissipation, and control including isolation of all energy sources.
- safe systems of work for maintenance on the bolting plant, including setting of controls
- operator protective structures requirements
- trouble shooting guide

- recommended spares
- emergency procedures.

4.12 Installation and commissioning

The owner and/or mine operator should install and commission bolting systems following the design documentation and specific site requirements.

The designer/manufacturer/importer/supplier should develop a commissioning plan/program/procedure for the bolting plant including, but not limited to:

- potential hazards and risks associated with commissioning the bolting plant
- examination and tests to verify the correct function and operation of all safety devices and controls using the mechanical and electrical commissioning checks
- means to document results of commissioning checks (checklist, work orders)
- a competent person(s) familiar with the installed system should do the commissioning examination and tests
- wet commissioning where a competent person(s) observes and checks the plant operation during normal production cycle(s) for an agreed period (e.g. one week) should be as agreed between the designer/manufacturer/importer/supplier and the Owner and/or Mine Operator
- a process to verify commissioning is complete and the system is ready for normal operation.

The mine operator should maintain and store commissioning records in the plant safety file for future reference. The designer/manufacturer/importer/suppler should update As-built drawings, specifications, and procedures on the completion of commissioning prior to the equipment being placed into service, and provide copies to the Owner and/or Mine Operator.

4.13 Inspection and test plan (ITP) - verification

The owner and/or mine operator should develop an inspection and test plan that:

- identifies all critical inspections, stops, and checks during the installation
- verifies the system is installed in accordance with the design documentation and the site standards, for example routing of hoses, component locations, etc
- will be completed prior to the normal operation of the system
- will be carried out by a competent person independent to the person that installed the system.

5. Plant operations

5.1 General

5.1.1 Plant safety file

The designer/manufacturer/importer/supplier should initiate a plant safety file and the owner and/or mine operator of the bolting plant should maintain the file. Safety-related aspects of bolting plant should be fully documented. The records should be maintained and cover the lifecycle of the system.

The plant safety file should have the following information as a minimum:

- design specifications, performance criteria and operational conditions
- design documentation as specified by the designer/manufacturer/supplier
- installation requirements
- hazard identification and risk assessment documents
- risk control methods
- identification of all safety critical systems and their levels of risk reduction
- consultation records
- commissioning and test results
- maintenance records, safety inspections and test reports
- change of procedures, monitoring, audit, and review reports
- reports of accidents and safety statistics
- plant alterations
- applicable electrical/mechanical certifications, test certificates, registrations, etc
- validation of compliance with standards, guidelines, etc.

The owner and/or mine operator should ensure records are readily retrievable and protect them against damage, deterioration, or loss. A plant safety file may not necessarily be one complete document. If so, the designer should refer the reader to the information's location.

The owner and/or mine operator should keep and maintain the plant safety file for the life of the installation.

5.1.2 Use of bolting plant

End users of bolting plant should ensure that:

- the bolting plant is used in accordance with its intended operational envelope and the designer's recommendations; (e.g., single pass, multi pass, cable bolting operations)

- bolting plant is not operated unless the operator is supervised and receives adequate information and training
- bolting plant is only used for the purpose for which it was designed, unless a competent person assesses that the change in use does not present an increase in risk to health and safety
- safety features are used as intended by the designer of the bolting plant
- safeguarding systems and/or other safety systems control the operator entanglement risk
- operators are not in the immediate area of remotely or automatically energised parts of bolting plant without appropriate controls and systems of work in place
- hot parts are adequately guarded
- there are measures to prevent unauthorised alterations or use of bolting plant
- bolting plant is subject to appropriate, tests, inspections, and maintenance necessary for safety
- if there is an immediate risk to safety, bolting plant is withdrawn from service.

5.1.3 Competencies

The owner and/or mine safety management system should address the minimum acceptable competencies for types of work being performed. Competencies may be:

- machine specific (i.e. for each type of bolting plant)
- for operators
- for maintenance people

Competencies should be reassessed at regular intervals.

As a minimum, the competencies should include:

- knowledge and understanding of the hazards and required controls
- safe operation, inspection, and testing of the plant
- operator safety inspections and operational maintenance activities
- reporting of faults and defects
- use of safeguarding systems
- bolting drilling process, using correct consumables, standards, and systems
- isolation of all energy sources
- strata support TARP’s
- knowledge of the relevant sections of the mining operation’s ground or strata failure principal hazard management plan.

5.1.4 Supervision

A competent person should direct all strata support and drilling activities.

The competent person should consider the following items before the commencement of strata support and drilling activity:

- the hazards of the location have been identified and the risks assessed
- controls are in place to eliminate or reduce risk
- that bolter operators are aware of potential hazards
- the plant being used has been inspected, is fit for purpose, and is safe to operate
- the bolting plant is operated in accordance with the mine’s TARPS’s, standards and procedures.

5.2 Operational standards and procedures

Operational standards and procedures should cover all work to be undertaken by competent operators and should include:

- pre-start checks
- hazard control
- isolation required for operational and maintenance work
- loading and unloading of supplies on and off the plant
- the strata support process which may include bolting and drilling activities, setting TRS, rib bolting, rib protection, interaction with cutting sequence if applicable, and supplies,
- roof support TARPs
- establishing and maintaining adequate ventilation
- emergency shutdown
- normal start/stop
- safe standing zones and
- other rules, standards, and procedures for safe operation.

5.3 Other matters

5.3.1 Isolation systems

The isolation of bolting plant should be consistent with the mine safety energy isolation standard, mechanical engineering control plan (MECP), electrical engineering control plan (EECP) and carried out using the EECP code of practice, MECP code of practice, designers, manufacturers, and supplier’s information.

5.3.2 Dry drilling

The mine operator should assess and adequately control the increased risk of methane ignition, dust concentration and dust disposal when dry drilling.

The mines airborne contaminants principal hazard management plan which identified and assessed the hazards should identify and control dry bolting hazards.

Note: Wet drilling/bolting typically reduces these risks and is the preferred method of drilling into the underground strata.

6 Maintenance and repair

The owner and/or mine operator and other users of bolting plant must ensure that in relation to repair and maintenance of the plant that:

- necessary facilities and systems of work are provided and maintained
- inspections, maintenance, testing, repairs, and cleaning is carried out with regards to designers, manufacturers information or otherwise developed by a competent person
- all safety features and warning devices on bolting plant are tested and maintained in an operating condition
- repair, inspection, and testing are carried out by a competent person
- repairs to bolting plant keep the bolting plant within its design limits
- machine design functionality is maintained including thrust and rotation speeds, torque, water flow, etc
- if access to the bolting plant is provided, the bolting plant is stopped and isolated, locked out, danger tag, permit or other control measure is used
- they maintain explosion protected electrical equipment under AS/NZS 2290, and a licenced repair workshop should carry out overhauls of electrical equipment that is explosion protected.

6.1 Maintenance

The owner and/or mine operator should develop and implement a proper examination, inspection, testing and maintenance system to ensure all bolting plant is fit for purpose, safe and without risks to health when properly used. The mine operator should develop this system based on site specific conditions, the designer's recommendations, or recommended by a competent person.

Where maintenance activities identify a design or manufacture fault that has potential to harm health or safety, information on the fault should then be provided to the designer, manufacturer, importer, or supplier.

The maintenance system should identify where any automatic functions can take place (e.g., shovel to floor when bolting mode is engaged) during maintenance activities. This should be included in the continuous miner or bolter miner and mobile bolter maintenance training.

The owner and/or mine operator of bolting plant should keep information regarding the maintenance activities on the bolting plant in the computerised maintenance management system and work orders (or similar).

Maintenance workers should be competent to work on the bolting plant and familiar with the maintenance recommendations.

All component repairs and replacements should be carried out to the designer's recommended specification in accordance with the mine site procedures.

Overhaul of bolting plant should return the plant to original design specification as a minimum, or upgrade to newer specification drill rigs and control systems where practical.

6.2 Maintenance management

The owner and/or mine operator of bolting plant should incorporate a maintenance management program into the operation of bolting plant to ensure satisfactory condition and operation while in service. The program should include, but not limit to, the following:

- pre-operational inspection and servicing including lubrication requirements
- periodic and or condition-based servicing
- periodic inspections and testing
- report and record defects identified on inspection and maintenance
- compliance auditing.

6.3 Alterations and repairs

A person must not carry out alterations to bolting plant unless the person carrying out the alterations fulfils the duties of a designer under the WHS Regulation 2017. A risk assessment should identify the alterations are safe and are able to be done without reduction to the overall plant safety.

Alterations of safety critical parts require a review of the integrity level or category.

The original designer or a competent engineer should direct the design and implementation of alterations to plant.

Repairs to plant are to be at least as functionally efficient as the original specification before the failure or damage.

The end user should conduct an operational risk assessment on the modified plant (e.g., using non-OEM components) before putting the machine into operation. This risk assessment should ensure that there are no new hazards introduced unless proper controls are implemented.

For any alteration and in conjunction with a change management process the designer, or competent person fulfilling the role of designer, should review all standards and documentation applicable to the bolting plant.

Appendix A: References

Definitions

NAME	DEFINITION
alter	In relation to plant, it means to change the design of, add to or take away from the plant where the change could affect health or safety. It does not include routine maintenance, repair, or replacement.
ancillary controls	Those controls which are not used in performing the bolting or drilling function but are used to service and configure the mobile bolting plant to suit roadway conditions such as, but not limited to – • driving / tramming the mobile plant • deploying operator protective systems, (e.g., TRS, canopy, roof guard, rib shield) • floor / stab jack • extendable platform • cable reel, boom control, mode select, brake valve, towing valve, etc.
automated temporary roof support (ATRS)	A device to provide temporary roof support from a location where the bolting plant operator is protected from roof falls.
bolting function	Includes the drilling process and installing strata support bolts.
bolting plant	Plant used to install and secure strata / ground support bolts in the roof, rib or floor of a roadway and includes the bolting rig, the rib bolter, and the machine in which the bolting rig or rib bolter is installed upon. For example, miner bolters, road headers, self-propelled bolters, mobile bolting plant, bolting platforms.
bolting rig	The machine used in the bolting process, capable of drilling a hole in the strata, inserting the support bolt, and developing torque to the bolt to apply strata support and includes, the drill motor, the drill mast, the control bank, and other associated components.
bolting platform	Any platform fitted with a minimum of one bolting rig, which is transported by a mobile plant carrier (e.g., QDS platform bolters on LHDs, ITs, tracks, monorails, etc.)
cable bolt pusher	The hydraulic system that feeds the cable bolt into a predrilled hole in the roof strata. This dramatically reduces the amount of physical input from the operator and in turn increases safety and productivity.
competent person	A person who has, through a combination of training, education, and experience, acquired knowledge and skills enabling that person to perform a specified task correctly.

NAME	DEFINITION
defect management system	A system outlines the actions to be taken when a fault is identified by documenting: • instructions to be undertaken • the details of the defect • actions taken to rectify the fault.
emergency stop device	A manually actuated control device the operator uses to initiate an emergency stop function. Refer stop controls
ergonomics	Is the science and practise of designing plant, processes, and environments to accommodate human limitations, and make optimal use of human capabilities. More simply put - considering principles of ergonomics in equipment design means designing equipment for people. The application of ergonomics principles enhances people's safety and productivity. Notes: 1. The Human Factors and Ergonomics Society of Australian Inc maintains a directory of Certified Professional Members (see www.ergonomics.org.au) 2. Guidance for ergonomics can be found in AS 4024; Part 1401: Ergonomic principles – Design principles – Terminology and general principles. 3. Specific examples of application to underground coal mining equipment can be found in the report of ACARP project C14016 Reducing injury risks associated with underground coal mining (www.acarp.com.au).
geotechnical engineer	A qualified and competent person with engineering expertise in analysing and assessing strata (geological) failure modes, performance and loading criteria.
ground or strata failure principal hazard management plan	The mine operator must prepare a PHMP for each principal hazard associated with mining operations at the mine. This is a mandatory requirement under Clause 52 and schedule 1 of the WHS (Mines and petroleum sites) Regulations and is specific to each mine. The Mine Operator should prepare the ground or strata failure principal hazard management plan by consulting a competent geotechnical engineer.
guard	Part of a machine specifically used to provide protection by means of a physical barrier. As per the requirements of AS/NZS 4024 series.
isolation and energy dissipation	A procedure which consists of all the four following actions: • isolating (disconnecting, separating) the machine (or defined parts of the machine) from all power supplies.

NAME	DEFINITION
	• if necessary (for instance in large machines or in installations), locking (or otherwise securing), all the isolation units in the isolation position. • dissipating or restraining (containing) any stored energy which may give rise to a hazard. Note: Energy may be stored in: • mechanical parts continuing to move through inertia • mechanical parts liable to move by gravity • capacitors, accumulators • pressurised fluids; and • springs • verifying isolation and/or energy dissipation is achieved. Best practice is to provide a lockable means of isolation.
licensed workshop	A facility that is licenced by the Regulator, under Part 10 of *Work Health and Safety (Mines and Petroleum Sites) Regulation 2022* to undertake any overhauling, repairing, or modifying activities that may affect the explosion protection properties of explosion-protected plant".
life cycle	Includes design, manufacture, construction or installation, commissioning, operation, maintenance, repair, decommissioning and disposal.
massive failure	A catastrophic failure of the strata into the installed strata support.
must	It is mandatory. Indicates that legal requirements exist and must be complied with.
mobile bolting plant	Any specifically designed bolting plant used for the purpose of bolting and with a self-contained traction system.
operator(s)	The worker(s) who has operational control over the bolting rig and includes any assistant as required for the drilling and bolting process.
operator protective canopy	A physical barrier designed to protect the operator from a roof fall or from large falling material (coal or stone, or both) from above the operator's workstation.
operator protective guard	A physical barrier designed to protect the operator from small falling material (coal or stone, or both).
operator protective system	Any system or means (risk control) of preventing injury to the operator(s) from material falling from either the roof or rib. Note: It may include any combination of operator protective structures, supported roof, supported rib, meshed roof or rib, geotechnical assessments, systems of work (strata failure management plan), PPE etc, to reduce the risk to the lowest level reasonably practicable.

NAME	DEFINITION
operator protective structure	A physical mechanical structure that protects the operator (e.g., a temporary roof support (TRS), rib protection shield, protective guard, protective canopy, etc.)
protective device	Safety devices (other than a guard) which eliminate or reduce risk, alone or associated with a guard. Note: AS/NZS 4024 series provides guidance on a range of safety protective devices.
plant	Reference: - Work Health and Safety Act 2011 No 10 Section 4. *plant* includes— (a) any machinery, equipment, appliance, container, implement and tool, and (b) any component of any of those things, and (c) anything fitted or connected to any of those things.
primary bolting controls	Frequently used controls that the operator normally uses to perform the bolting and drilling functions during the installation of strata support such as: • rotation • timber jack • feed
reasonably foreseeable misuse	Use of a machine in a way not intended by the designer, but which may result from readily predictable human behaviour.
remote control	Means the manual control of bolting plant by an operator from a position within natural visual and audible range.
rib bolter	A bolting rig that the operator uses for drilling and supporting the side walls of the heading.
rib protection shield	An operator protective device designed to limit or deflect any rib failure from the operator's workspace.
risk(s)	Combination of the probability of occurrence of harm and the severity of that harm.
risk analysis	Combination of the specification of the limits of the machine, hazard identification and risk estimation.
risk assessment	Overall process comprising a risk analysis and risk evaluation.
safeguarding system	A system of safety measures consisting of the use of a combination of guards and other protective devices (safeguards) to protect operators from hazards which cannot be reasonably eliminated or sufficiently limited by design.
risk management	Involves the process of identifying hazards (inspection of the workplace), assessing the risk posed by each hazard (likelihood/consequence), developing

NAME	DEFINITION
	controls to manage the risk and effective implementation of policies, practises, and procedures.
safe speed of operation	An operating speed sufficiently slow such that an operator can recognise and avoid a potential hazard.
safety critical	Those risk controls that are essential for the safe use of bolting plant, the malfunction of which would immediately increase the risk of injury or damage to health. Note: There are three types of safety critical systems: • safety specific, specifically intended to achieve safety (e.g., two-handed control, sequencing, guard) • interlocks, emergency stop, operator protective devices, and • safety related, non-safety specific (e.g., manual control during set-up, speed, temperature control, etc.)
safeguarding system	A system of safety measures consisting of the use of a combination of guards and other protective devices (safeguards) to protect operators from hazards which cannot be reasonable eliminated or sufficiently limited by design.
secondary controls	Infrequently used controls that the operator normally uses to position and configure the bolting rig before carrying out the drilling and bolting functions, such as: • tilt • traverse • slew • rig raise • rib slide • side shift • shield tilt • gripper • guide clamp • percussion.
self-propelled bolters	Any specifically designed machine, requiring an integrated traction system, and having a minimum of one bolting rig (e.g. a longwall face bolter).

NAME	DEFINITION
semi-automatic	Automation of the drilling part of the bolting process.
should	A recommended course of action.
single-handed operation	Any manual control requiring the use of a single hand for the function to operate at a safe speed of operation.
skin failure	A failure around installed roof or rib supports. It includes both large material and small brat falling.
stop controls	Emergency Stop (E-Stop) – when applied removes all energy sources from the item of plant. Refer to Category 0 in AS 4024.1604 Safety of machinery – Design of controls, interlocks and guarding – Emergency stop – Principles for design, and AS 4024.1204 – Electrical equipment. For example, on a continuous bolter miner when the emergency stop is activated all electrical power to the miner is tripped to the machine at the DCB. Machine Stop – when applied removes all energy from the operational areas of the item of plant but does not remove the incoming power to the plant. Refer to Category 1 in AS 4024.1604 Safety of machinery – Design of controls, interlocks and guarding – Emergency stop – Principles for design, and AS 4024.1204 – Electrical equipment. For example, on a continuous bolter miner, the power is removed from all operational functions of the machine, however, the main electrical enclosure and machine interface/diagnostic screen remain energised. Machine stops are often considered by some mines and manufacturers to have the operational functionality of emergency stops. Generally, in particular situations the mines and manufacturers/suppliers have made a risk-based decision following formal design, operation, and maintenance risk assessment that in the event of an emergency, the machine can be repowered at the machine without the time required to reset the power outlet at the DCB which can be hundreds of meters away. Hydraulic Stop – when applied dissipates all system pressure on the machine by draining fluid back to tank, except those items that are specifically held by load locks to prevent unintended movement, or for other health and safety reasons. Individual drill rigs on a machine may also have a hydraulic stop on the control valve bank that only deenergises that particular drill rig. When considering the potential for future autonomous drill and bolt functionality, the following stops should reference AS 17757.2020 – Earth

NAME	DEFINITION
	moving machinery and mining – Autonomous and semi-autonomous machine system safety: All stop (A-Stop) – allows the autonomous system operator to disable all autonomous equipment operations within the autonomous operating area Remote stop (R-Stop) – similar to an All Stop but carried on operators, or in the cabin of person operated machines, when entering the autonomous operating area.
supported rib	Any portion of the roadway outbye the last line of permanently installed rib support, or otherwise as determined and documented by the mines ground or strata failure principal hazard management plan.
supported roof	Any portion of the roadway outbye of the centre line of the last line of permanently installed roof support or as otherwise determined and documented by the mines ground or strata failure principal hazard management plan.
repair	Restore to original design condition.
temporary roof support (TRS)	A short duration reactive support applied to the strata providing support to the immediate roof (between the last line of support and the temporary roof support) to protect the operator during support installation. TRS includes an ATRS above the operator.
two-handed operation	A protective device(s) that requires at least simultaneous actuation by both hands to initiate and to maintain bolting machine functions, thus providing a protective measure only for the person who actuates it.
users of bolting plant	Means any company or person which owns or has control of bolting plant where the bolting plant is used by the company's employees or employees of another company including mine operators, hire companies, contracting companies, etc.

Abbreviations

Abbreviation	Name
AS	Australian standard
AS/NZS	Australian/New Zealand standard
ATRS	Automated temporary roof support
HSMS	Health and safety management system
ISO	International Standards Organisation

Abbreviation	Name
MSD	Musculoskeletal disorders
OEM	Original equipment manufacturer
PCBU	Person conducting a business or undertaking
PPE	Personal protection equipment
QDS	Quick detach system
SMS	Safety management system
TRG	Technical reference guide
TRS	Temporary roof support
WHS Act	*Work Health and Safety Act 2011*
WHS (MPS) Act	*Work Health and Safety (Mines and Petroleum Sites) Act 2013*
WHS Regulation	Work Health and Safety Regulation 2017
WHS (MPS) Regulation	Work Health and Safety (Mines and Petroleum Sites) Regulation 2022

Standards

ABBREVIATION OF STANDARD	TITLE OF STANDARDS
AS/NZS 1269.1	Occupational noise management
AS/NZS 1418.10	Cranes, hoists, and winches – Mobile elevating work platforms
AS 1657	Fixed platforms, walkways, stairways, and ladders - Design, construction, and installation
AS/NZS 2290.1	Electrical equipment for coal mines - Introduction and maintenance - For hazardous areas
AS 2381	Electrical equipment for explosive gas atmospheres - Selection, installation, and maintenance
AS/NZS 60079.17	Explosive atmospheres Electrical installations inspection and maintenance
AS 2671	Hydraulic fluid power – General requirements for systems.
AS/NZS 3000	Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 3800	Electrical equipment for explosive atmospheres for overhaul
AS/NZS 4024 Series	Safety of machinery
AS/NZS 4024.1302	Safety of machinery. Part 1302: Risk assessment – Reduction of risks to health from hazardous substances emitted by machinery – Principles by machinery – Principles and specifications for machinery manufacturers

ABBREVIATION OF STANDARD	TITLE OF STANDARDS
AS/NZS 4024.1401	Safety of machinery. Part 1401: Ergonomic principles – Design principles – Terminology and general principles.
AS/NZS 4024.1903	Safety of machinery. Part 1903: Displays, controls, actuators, and signals – Ergonomic requirements for the design of displays and control actuators – Control actuators
AS/NZS 4024.1906	Safety of machinery. Part 1906: Displays, controls, actuators, and signals – Indication, marking and actuation – Requirement for the location and operation of actuators
AS/NZS 4024.2601	Safety of machinery. Part 2601: Design of controls, interlocks and guarding – Two-hand controls devices – Functional aspects and design principles
AS 4100	Steel structures
AS/NZS 4240.1	Remote Control for Mining Equipment
AS/NZS ISO 45001	Requirements with guidance for use Occupational health and safety management systems - Requirements with guidance for use
AS/NZS 4804	Occupational health and safety management systems - General guidelines on principles, systems and supporting techniques
AS 4871 series	Electrical equipment for coal mines, for use underground
AS 31000	Risk management – Principles and guidelines Now
AS ISO 31000	Risk management guidelines
AS 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems - Functional safety and AS 61508
AS/NZS 62061	Safety of machinery - Functional safety of safety-related electrical, electronic, and programmable electronic control systems
SA/SNZ HB 205	OHS Risk management handbook
AS/NZS 4240.3	Remote control systems for mining equipment Operation and maintenance for underground coal mining

ISO and IEC Standards

Abbreviation	Title of Standard
ISO 12508	Earth-moving machinery — Operator station and maintenance areas — Bluntness of edges
ISO 13407	Human-centred design processes for interactive systems
ISO 13851	Safety of machinery - Two-hand control devices - Functional aspects and design principles
ISO 31010	Risk management - Risk assessment techniques
ISO 45001	Occupational Health and Safety Management Certification

Appendix B: further information

Technical Reference Guideline / Mining Design Guideline

The following Technical Reference Guidelines (TRG) and Mining Design Guideline (MDG) are useful reference documents in relation to strata support equipment.

TRG / MDG	Title
MDG 1	Free steered vehicles in underground coal mines
MDG 10	Design guidelines for hydraulic load locking valves for use in coal mines (unless specifically superseded by TRG 41)
MDG 17	Construction of continuous miners
MDG 40	Guideline for hazardous energy control (isolation or treatment)
MDG 41	Fluid power systems
TRG 39	Braking systems on plant used in underground transport (MDG 39)
TRG 41	Fluid power (MDG 41) (if already published at time of publishing this doc)
TRG 3608	Non-metallic materials for use in underground coal mines and reclaim tunnels in coal mines (MDG 3608)

Safety Alerts/Safety Bulletins

The Resources Regulator issued the following Safety Alerts (SAs) and Safety Bulletins (SBs) in relation to strata support.

SA/SB No.	Title
SA23-02	Serious injury of a Jumbo offsider during drilling work
SB23-06	Rockfall injuries to workers increase in underground mines
SB22-04	Hand injuries (including fingers and thumbs)
SB22-02	Strata failures increase in underground coal mines across the state
SA20-02	Roof fall buries continuous miner
SB19-15	Rapid face bolter incidents
SB18-12	Rib Failures in underground coal mines
SA17-05	Hand injured by fall of drill rods

SA/SB No.	Title
SB16-01	Bolting rig injuries
SA11-08	Fall of rib results in fatality
SA09-05	Mine worker crushed against rib by remote-controlled continuous miner
SA08-12	Anti-friction washer ignites
SA08-05	Miner's arm injured using drill rig
SA06-21	Drill rig incident
SA05-05	Drill Rig Serious Injuries
SA04-04	High Pressure Air Hose Burst on Exploration Drill Rig
SA01-13	Fall of coal and stone kills miner
SA01-01	Coal mine fatality from fall of roof
SA00-25	Serious injury while roof bolting

For further information contained in all Safety Alerts, Safety Bulletins and Weekly incident summaries you can conduct a safety search of the Resources Regulator's webpage: https://www.resourcesregulator.nsw.gov.au/safety/safety-resources/safety-alerts-and-bulletins

Investigation reports

Rib failure at Clarence Colliery, 4 July 2018:
https://www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0020/1219142/Clarence-Colliery-Rib-failure-at-Clarence-Colliery-Investigation-report.pdf

Double fatality due to major rib/sidewall pressure burst, Austar Coal Mine, 15 April 2014:
https://www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0006/583125/Investigation-Report-Austar.pdf

Fatal injury to worker by falling coal slab, Chain Valley Colliery, 3 June 2011:
https://www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0012/458985/Published-report-Chain-Valley-fatality.pdf

Injury resulting in death involving a mobile bolter, Myuna Colliery, 25 July 2008:
https://www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0011/393446/Bolting-rig-ejection-of-drill-steel-Myuna-Colliery-Investigation-report.pdf

Serious injury involving roof bolter, Austar Coal Mine, 3 March 2008:
https://www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0007/267730/Bolting-rig-inadvertant-rotation-UG-coal-Austar-mine-summary-investigation-report.pdf

Enforceable undertakings

Review of roof bolting machines: WHS enforceable undertaking - Centennial Myuna and Sandvik Construction Redhead.
https://www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0004/532930/Agreed-undertaking-Review-of-Mobile-Roof-Bolting-Machines-Project-Industry-Report.pdf

Enforceable undertakings and WHS undertakings are published on the Resources Regulator's website at: https://www.resourcesregulator.nsw.gov.au/compliance-and-enforcement/enforceable.

ACARP reports

Recommendations about direction control-response relationships are provided in the final report of ACARP Project C16013 Principles for the reduction of errors in bolting control operation.
https://www.acarp.com.au/abstracts.aspx?repId=C16013

Appendix C: Bolting process maps

This following roof bolting process map and rib bolting process map are examples only. Each manufacturer and mine will have specific process maps aligned with the drill rig equipment and the mine’s environmental conditions, requirements, and procedures.

ROOF BOLTING PROCESS

Be aware of strata management requirements

1. Prepare to install support
- Ensure suitable PPE is worn
- Pre-install mesh over TRS and Bolters
- Move host machine forward into bolting position
- Set TRS to support the roof
- Select Bolting mode
- Extend Rib Shield/Platform for operator protection
- Access roof bolting workarea
- Always remain under supported strata when conducting bolting operations

2. Prepare to drill hole
- Precheck-drills, adaptors, consumables for integrity
- Insert washer plate in headplate
- Install drill in chuck and drill guide (headplate/ guide jaws)

3. Position bolter
- Tilt/traverse bolter to position new drill hole
- Set drill bit to contact strata
- Set timberjack to contact strata

4. Drill bolt hole into strata
- Activate rotation
- Activate drill feed

} AUTO DRILL-two-step initiation

- Activate and/or ensure drill flushing medium has started
- Drill hole to full depth of drill steel
- Retract drill from roof strata
- CAUTION–do not retract drill tip if potentially blocked (hot drill tips can ignite methane gas under the right conditions)
- Remove drill from bolter

4.1. Drill cable bolt hole
- Drill hole to full depth of first drill
- Apply gripper to hold drill
- Unscrew joint
- Lower drillhead
- Insert new extension drill
- Release gripper
- Continue drill process to full depth
- Remove drills from strata/bolter

5. Install bolt into strata
- Raise drillhead to suitable work height
- Secure tightening spanner in chuck
- Insert chemical anchoe and bolt into strata
- Engage bolt/cable in spanner and feed into strata
- Mix chemical anchor and wait for setting time
- Torque bolt until drillhead stalls
- Retract drillhead and remove tightening spanner

Additional bolts-repeat steps 3 to 5

6. Park bolter
- Fully retract bolter drillhead and timberjack
- Raise drillhead up bolter to protect hoses
- Tilt/slide bolter to park position
- Retract TRA and Rib Shield

Select Mining Mode

Load/store consumables
- Bolts
- Chemical anchors
- Washer plates
- Roof mesh
- Rib mesh
- Drill steels
- Tightening spanners
- Adaptors

RIB BOLTING PROCESS

Be aware of strata management requirements

1. Prepare to install support
- Ensure suitable PPE is worn
- Extend Rib Shield/Platform
- Select Bolt mode
- Access rib bolting work area
- Always remain under supported strata when conducting bolting operations
- Install mesh along rib and secure in place

2. Prepare to drill hole
- Precheck - drills, adaptors, consumables for integrity
- Insert bolt washer plate on headplate
- Install drill in chuck and drill guide (headplate/ guide jaws)

3. Position bolter
- Tilt rib bolter to position new drill hole
- Set drill steel to strata
- Set timberjack to strata

4. Drill bolt hole into strata
- Activate rotation
- Activate drill feed

} Two handed operation

- Activate and/or ensure drill flushing medium has started
- Drill hole to full depth
- Retract drill from strata
- CAUTION – do not retract drill tip if potentially blocked (hot drill tips can ignite methane gas under the right conditions)
- Remove drill from bolter

5. Install bolt into strata
- Secure tightening spanner in chuck
- Insert chemical anchor and bolt into strata
- Engage bolt in spanner and feed bolt into strata
- Mix chemical anchor and wait for setting time
- Torque bolt until drillhead stalls
- Retract drillhead and remove tightening spanner

Additional bolts - repeat steps 3 to 5

5.1. For mechanical bolts
- Secure tightening spanner in chuck
- Insert rib bolt into strata
- Engage bolt in spanner and feed into strata
- Rotate to torque bolt
- Retract drillhead and remove tightening spanner

6. Park bolter
- Retract bolter drillhead and timberjack
- Lower bolter into park position
- Retract Rib Shield