



HMS Consultants Australia Pty Ltd

**Department of Trade and Investment,
Regional Infrastructure and Services,
Centennial Myuna Pty Ltd and Sandvik
Mining & Construction Redhead Pty Ltd**

NSW Mining Workplace Agreed Undertaking Syd15181.2 - Review of Mobile Roof Bolting Machines Project Report

May 2014

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Regional Infrastructure and Services,
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Syd15181.2 - Review of Mobile Roof Bolting
Machines Project Report**

May 2014

Author:

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This Report was prepared on the basis of information collected by HMS from NSW Underground coal mines and other sources using the approved Review Evaluation Tool. As this is a denatured industry baseline report, there is no mention of findings relating to individual mines.

File	Report	Prepared By	Peer Review By	Date
20131127 HMS Centennial NSW Mining Workplace Agreed Undertaking Report – David Swan	Draft	D. Swan	C. Allanson	8th Oct '13
20131127 HMS Centennial Sandvik NSW Mining Workplace Agreed Undertaking Final Report	Final	D. Swan	The Parties	May 2014

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Appendix A – Review of Coal Services Incident Data

Appendix B – Review Evaluation Tool

1. Acknowledgements

HMS Consultants Australia Pty Ltd (“HMS”) wish to thank the following organisations, coal mines and NSW Mining Workplace Agreed Undertaking, reference number; Syd15181.2 (“Undertaking”) governance groups for the tremendous support and assistance provided to HMS during the course of performing the specified Project activities as outlined in the Undertaking.

- Department of Trade and Investment, Regional Infrastructure and Services (“Department”)
- Construction, Forestry, Mining and Energy Union (“CFMEU”)
- Undertaking – Project Steering Committee
- Undertaking – Project Technical Working Group
- Centennial Coal Pty Ltd (“Centennial”)
- Sandvik Mining and Construction Australia Pty Ltd (“Sandvik”)
- JoyGlobal
- Owners, management and employees of the participating 28 NSW underground coal mines.

2. Executive Summary

On the 24 July 2008, a coal miner working at Myuna Colliery, situated on Lake Macquarie, about 35km from Newcastle, was injured while operating a mobile bolting machine that resulted in a fracture of the fifth metatarsal of the left foot.

On the 4 September 2008, the worker died as a result of a pulmonary thrombo-embolism.

Following this death, Centennial and Sandvik together with the Department, the Parties, engaged in a NSW Mining Workplace Agreed Undertaking. This is the first such Undertaking conducted in the NSW coal mining industry.

The Parties believe that the key benefits of the Undertaking should be;

- The Undertaking will enhance industry awareness and knowledge of hazards associated with the installation of roof bolts in underground coal mines
- This practical review of each underground coal mine in NSW will identify areas for improvement
- The Project will enable mines to make improvements that will reduce the likelihood and severity of bolting rig injuries
- The Project will benefit workers as bolting practices will be safer across the industry

Both Centennial and Sandvik have made a statement of regret regarding the incident at Myuna, however neither party concedes any breach of the *Occupational Health and Safety Act 2000 (NSW)* ("OHS Act"). The companies and their management are committed to the health and safety of all persons in the workplace and those who use their equipment.

In November 2012, HMS was selected by Centennial and Sandvik via a tender process to perform the "Undertaking Project Activities" as outlined in the *NSW Mining Workplace Agreed Undertaking, reference number Syd15181.2, Section 4.1, Project Activities* on behalf of Centennial and Sandvik.

Apart from the incident that initiated this Undertaking, a review of NSW industry accident and incident databases over the decade to 2012 indicated there were 554 recorded entries in the Department's COMET database and 841 recorded entries in the Coal Services database of bolting-related incidents. An analysis of incident databases can be found in [Section 6.3 - Review of Industry Incident Databases](#) of this Report.

This review identified 155 operational mobile bolting machines across the 28 operational underground coal mines. Of these machines 63% are bolter continuous miners and the remainder are a broad range of mobile bolters. Approximately 45% of machines were manufactured or underwent major overhaul since 2010, the last revision date for MDG35.1 - Guideline for Bolting and Drilling Plant in Mines ("MDG35.1").

A desktop review of mobile bolting machines with manufacturers highlighted the evolution of mobile bolting equipment, some examples of the evolution include:

- Controls introduced to avoid injury due to the operator's proximity to bolting hazards
- Controls introduced relating to inadvertent operation of equipment

- Controls introduced to overcome ergonomic hazards
- Self-drilling bolts to reduce the frequency of handling and interactions between operators and rotating equipment

Findings relating to the desktop review with manufacturers are summarised in [Section 6.4 - Desk Top Review of Selected Machines](#) of this Report.

The general industry consensus is, that the solution for reducing the risk of personal injury associated with future mobile bolting activity is a combination of;

- Remotely operated bolting functions
- New strata reinforcement technologies

Regarding remotely operated bolting functions an additional technology enhancement would be for the capability to be able to “scan” the strata to determine its’ geological/ geotechnical characteristics and match these characteristics to a pre-determined strata reinforcement regime. This process could replace the human making decisions on roof reinforcement type and density currently made by reference to Trigger Action Response Plans.

There are currently a number of industry and private projects looking at various aspects of this solution, but it is unclear if a holistic approach overseeing the range of initiatives exists.

The outcome from the site visit program identified good compliance with most items covered by the Evaluation Tool, (a tool specifically developed for this Review) for the newer generation mobile bolting equipment. Many of the new generation design features are not available to operators due to the age of the equipment that they operate. Further, based on scheduled equipment replacement programs, it is anticipated that many operators will not benefit from these improvements for some time.

Therefore, in the short term, without replacement or upgrades to older equipment, it is likely that the type and prevalence of injuries people experience whilst operating mobile bolting equipment will continue. Findings and recommendations relating to the site visit program are summarised in [Section 6.5 - Mine Site Review of Selected Machines](#) of this Report.

The response from the coal mining industry to the Undertaking was very positive with all 28 operating underground coal mines participating in the detailed review of selected machines.

In addition, both JoyGlobal and Sandvik participated in a review of the evolution of the mobile bolting machine and shared their views on the future state of strata reinforcement technologies.

All Project KPIs were achieved and the mine site satisfaction survey KPI exceeded the ambitious target that was set at the commencement of the Project.

It can be reasonably concluded that this Project was very successful, with excellent engagement and participation from all Parties and the industry in general.

The Project principal recommendations follow;

Principal Recommendations;

1. Communicate the Undertaking Process, Findings and Recommendations to the coal mining industry utilising a combination of existing mechanisms as well as specific regional presentations
2. Individual mine sites to;
 - i. Diligently implement agreed actions resulting from the Undertaking mine site visits
 - ii. Conduct a gap analysis of their mobile bolting equipment against the findings in this Report and develop actions to close gaps
3. Update MDG 35.1;
 - i. Reflect proven technology advancements since its last revision
 - ii. Consider findings in [Section 6.5 - Mine Site Review of Selected Machines](#) of this Report
 - iii. Include a specific section in the Guideline on the storage of drilling consumables
 - iv. To provide for and encourage innovation
4. Improve mobile bolting equipment incident reporting to clearly identify the machine type/ make and incident failure mechanisms

3. Context

3.1 Technology Background

The introduction of strata bolting technology into the NSW coal mining industry during the 1970's was a step change in improving the control of strata surrounding underground roadways. Soon after the introduction of this technology, mines commenced retro-fitting bolting rigs onto continuous miners and other mobile equipment, with some of the earliest adaptations at West Wallsend No.2 Colliery in the lower Hunter Valley.

The introduction of strata bolting technologies quickly gained momentum and before long had mostly replaced the age old strata support of "timber or steel props/ sets" used to support strata in coal mines.

By the 1990s bolting rigs were routinely attached to continuous miners and other mobile equipment.

Although new strata control technology improved roadway structural integrity and hence the safety of underground workers a total system including the design, operability and maintainability of equipment to install this new technology as well as specific training and competency requirements did not exist and the industry struggled with this issue for decades injuring many people as well as exposing persons to an unquantifiable number of "uncontrolled release of energy" events.

From around early/ mid 2000 manufacturers commenced to integrate bolting technology into the overall machine design.

An analysis of the Coal Services database indicates 841 persons have made a compensation claim during the 10 years to 2012, and the Departments COMET database indicates numerous events such as unplanned movement of bolting machines or bolting rigs (equipment malfunction), escapes of fluid under pressure not striking anyone and damage to explosion protection devices. See [Section 6.3 - Review of Industry Incident Databases and Appendix A – Review of Coal Services Injury Data](#) for detailed information.

More recently the coal mining industry has recognised the importance of a total system approach to managing operational health and safety risk and subsequently there has been significant and accelerated improvement in the design, operability and maintainability of mining equipment as well as the development of specialised training modules and the use of equipment simulators.

New generation mobile bolting equipment has benefited from this approach with notable improvements in the design of physical work area by ergonomics specialists, use of electro-hydraulic systems for more precise operation and data gathering, improved protection from moving parts and energy sources. See [Section 6.4 – Desk Top Review of Selected Machines](#) for a more comprehensive list of improvements.

3.2 What is a Workplace Agreed Undertaking?

OHS Act 2000

Prior to 1 January 2012, with the introduction of the *Work Health and Safety Act 2011*, there was no provision for an 'Undertaking' of this sort. The *Occupational Health and Safety Act 2000* only had provision for prosecution.

Therefore, on 25 February 2010, charges were filed against both Centennial and Sandvik in relation to a contravention of the OHS Act.

On 16 March 2011, both companies made representations to the Director General, who agreed an appropriate course of action would be for both companies to enter into an Undertaking. On 24 March 2011 the charges were withdrawn in favour of the Undertaking, namely the; NSW Mining Agreed Undertaking Syd15181.2.

The Undertaking Syd15181.2 can be viewed on the following web address.

<http://www.resourcesandenergy.nsw.gov.au/miners-and-explorers/safety-and-health/major-investigations/whs-undertakings>

NSW Work Health and Safety (WHS) Undertaking – Current Legislation

In the event of an alleged contravention of the *Work Health and Safety Act 2011* ("WHS Act"), NSW Trade & Investment may, as an alternative to prosecuting the contravention, accept a WHS Undertaking given by the person who is alleged to have committed the contravention.

A WHS undertaking is used where the alleged contravention is of a serious nature.

WHS Undertakings accepted by NSW Trade & Investment will form part of the duty holder's compliance history.

A WHS undertaking is a high level sanction which is a legally-binding agreement between NSW Trade & Investment and the person who proposed the undertaking.

Once accepted by NSW Trade & Investment, the WHS undertaking obliges the person to carry out the specific activities outlined in the undertaking.

The activities are intended to improve not only health and safety at the workplace, but also deliver health and safety initiatives to the relevant industry and the broader community.

The activities are substantial.

When a proposed undertaking is accepted, any legal proceedings connected to the alleged contravention are discontinued.

Where legal proceedings have not been instituted, acceptance of the undertaking will mean that no proceedings will be commenced, subject to the undertaking not being contravened.

3.3 Workplace Agreed Undertaking Governance

The Undertaking Governance was a very important element in assuring that this Project achieved a high level of acceptance by the NSW coal mining industry including, the processes undertaken as well as material improvements to mobile bolting equipment practices.

The following governance “groups” were assembled for the duration of the Undertaking;

- Project - Steering Committee
- Project - Technical Working Group

The Project Steering Committee reports to the Deputy Director General. Its members include;

- Jenny Nash, NSW Trade & Investment, Director Mine Safety Performance
- Steve Bracken, Chief Operating Officer, Centennial
- Rowan Melrose, President, Sandvik
- David Simm, District Check Inspector, NSW Northern District, CFMEU

The Technical Working Group provides advice to the Project Steering Committee on specific health and safety matters relating to bolting and the quality of deliverables. Its members include two persons from each of Centennial, Sandvik, CFMEU and the Department.

Mr Mark Freeman, Senior Investigator & Compliance Officer, Mine Safety Performance, NSW Trade & Investment provided general Undertaking guidance, Undertaking communications and support as well as monitoring of the project on behalf of the Department.

Mr Peter Smith, General Manager - Health, Safety, Environment & Community, Centennial as well as Barry Wright, Mining Applications Manager and Shane Harrower, Product Development Coal & Minerals UG Drilling were nominated as the contact officers representing the Parties.

The Project Co-ordinator responsible for delivering the Undertaking Project activities and communicating with the contact officers was Mr David Swan, HMS Managing Director and author of this Report.

David chaired regular Project meetings with Mr Mark Freeman and the contact officers. The meeting reviewed the Project activity progression against plan and site satisfaction survey results as well as resolved any emerging Project issues.

4. HMS Project Activities

4.1 Project Activities Scope

The scope of this Project was to review the use of mobile bolting equipment at NSW underground coal mines. Where multiple machines were in operation at a site, the newest and oldest machines operating were subject to the review.

The review focused on the asset life cycle elements of; design, operability and maintainability as well as training.

Specific reference materials for the Project consisted of;

- Common Mines Environment Database (“COMET”)
- Coal Mining Services Australia (“Coal Services”) claims database
- MDG 35.1 Guideline for Bolting and Drilling Plant in Mines
- AS 4024.1; 2006 Safety of Machinery
- *Work Health and Safety Regulation 2011* Chapter 5
- The Myuna Incident; Investigation Report
- Related Safety Alerts and Safety Bulletins published by the Department
 - Safety Alert SA08-05; Miners arm injured using drill rig
 - Safety Alert SA05-05; Drill rig serious injury
 - Safety Alert SA99-16; Continuous miner drill rig fatally crushes tradesman
 - Safety Alert SA00-25; Serious injury while roof bolting

4.2 Project Deliverables

The key Project deliverables required by the Agreed Undertaking Activities were;

- Project Plan
- Review of relevant incident data (Appendix A)
- Site Visit Schedule
- Development of an Evaluation Tool/ Database (Appendix B)
- Pre-site Visit Information Request Form
- Site Visit Notification Protocol
- Generic Site Visit Protocol
- Site Feedback Report
- Site Visit Satisfaction Survey Form
- Monthly Project Report Form
- Aggregated, denatured Industry Report, this Report

4.3 Project Stages

The Project consists of four (4) discrete stages, which were to be delivered during an eighteen (18) month period. The Undertaking was signed in late March 2012, therefore for planning purposes HMS nominated the completion date to be the end of September 2013.

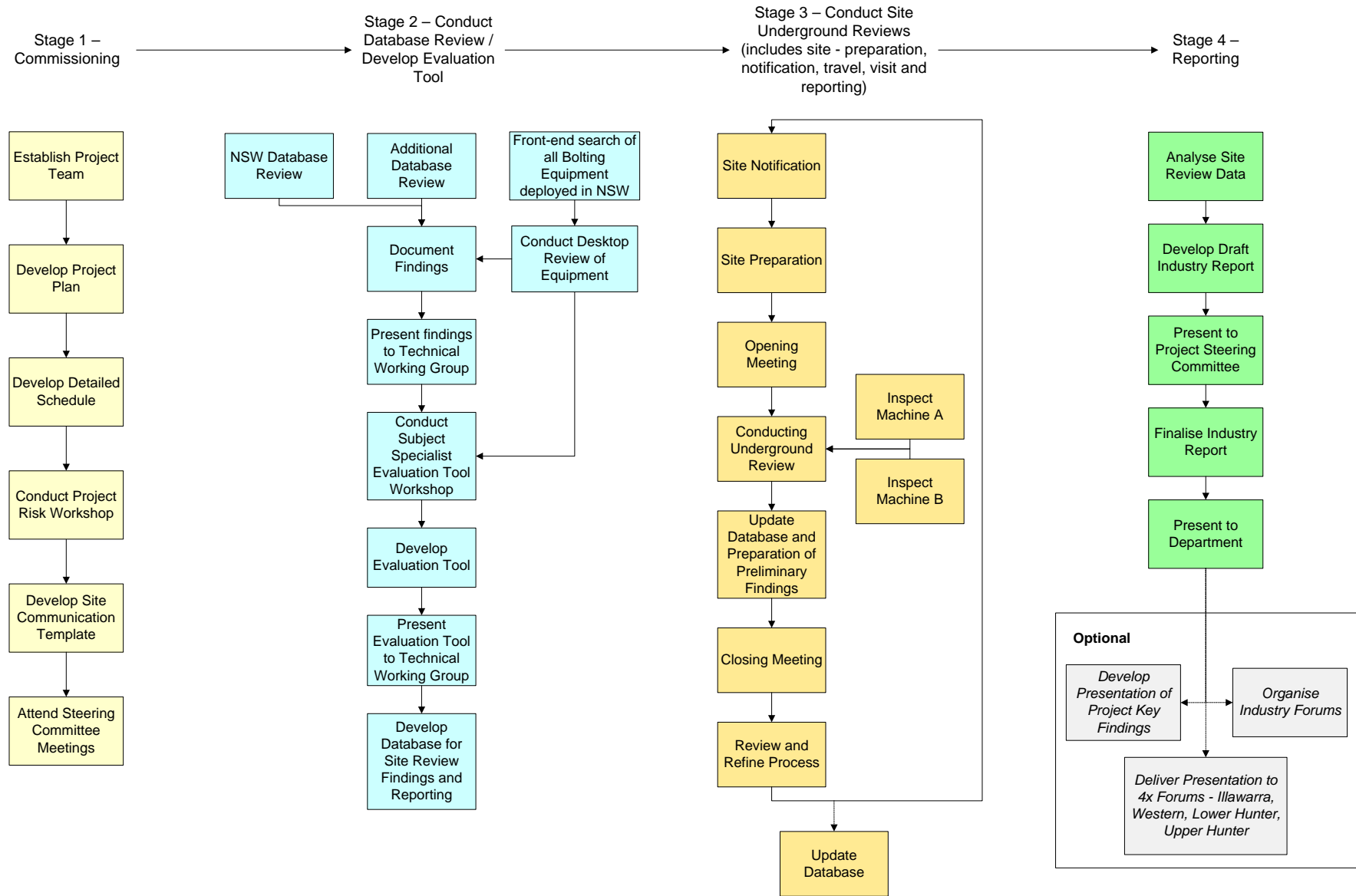
The four (4) stages and their completion dates are shown following;

Stage 1 – Commissioning	30 December 2012
Stage 2 – Studies and Site Visit Preparation	28 February 2013
Stage 3 – Site Visits & Studies	30 August 2013
Stage 4 – Reporting	30 September 2013

Following discussions with the key Project stakeholders as well as holding internal workshops HMS designed a Project delivery process for conducting the Undertaking activities.

The Project delivery process map is shown on the following page.

PROJECT PROCESS MAP



4.4 Project Planned KPIs

The planned Project Key Performance Indicators (“KPIs”) follow in *Table 1 – Project Planned KPIs*

KPI Description	Planned
Strong participation of NSW underground coal mines	>80% of mines
Positive Satisfaction Survey results from participating sites	>4 average rating
Project completed within timeline	Zero over-run
Acceptance of findings by Steering Committee	>90%
Project Health, Safety, and Environmental Incidents	Zero

Table 1 – Project Planned KPIs

4.5 Project Delivery Personnel

HMS assembled a very experienced and capable Project delivery team with a broad range of skills. The Project team members and some of their skills follow in *Table 2– Project Delivery Personnel*

Team Member	Expertise
David Swan	HMS Managing Director Project Co-ordinator
Peter Foster	Mining Engineer - Mine Manager Certificate of Competency Mine Rescue Certificate of Competency Certified OHS Auditor
David Clark	Mechanical Engineering Diploma Master of Engineering Mechanical Engineering Certificate of Competency
Robin Burgess-Limerick	PhD CPE Certified Member of the Human Factors and Ergonomics Society of Australia
Peter Graham	Metallurgist Specialist in Asset Management and Process Control
Michael Coull	Mining Engineer - Mine Manager Certificate of Competency Mine Rescue Certificate of Competency Certified QSA Auditor
Andrew Whalan	Mechanical Engineer Mechatronics Engineer Computer Science Engineer

Table 2 – Project Delivery Personnel

4.6 Review of Industry Incident Data

HMS conducted a review of the Coal Services and COMET databases mobile bolting incidents to gain an understanding of the type and distribution of injury mechanisms. The learnings from the review of incident data were an important input into the Undertaking Evaluation Tool that was used during the site visits.

4.7 Site Visit Schedule

All mines were notified by the Department of the review of underground mobile bolting practices in NSW. On the 25 February 2013 HMS emailed all NSW Underground coal mines a NSW Mining Workplace Mobile Bolter Undertaking Information Pack. This Information Pack included an overview of the NSW Agreed Undertaking and an outline on how HMS was going to complete each mine site visit.

4.8 Desktop Studies

HMS conducted a desktop study of mobile bolting machines, two (2) from both JoyGlobal and Sandvik. The desktop study focussed on three primary considerations;

- What was the “norm” for mobile bolting machines ten (10) years ago
- What do the most recent generation mobile bolting machines offer in improved health and safety performance for the industry
- What are the opportunities for reducing residual mobile bolting activity risks in the future

4.9 Mine Site Visit Process

HMS developed a Mobile Bolting Equipment Evaluation Tool (Evaluation Tool) (see Appendix B) based on the Undertaking criteria. This tool was subsequently endorsed by the Undertaking Technical Working Group before the “pilot” mine site was selected.

A mine was selected as the “pilot” site for the site reviews. Three HMS personnel attended the review over two days. The review process was discussed at length and amendments were made to the Evaluation Tool to enhance the relevance of the review process for the remainder of the mine visits.

Each mine was also sent the Agreed Undertaking Mobile Bolting Site Notification Form – indicating what was required from the Mine to complete the review.

In summary, the site visit commenced with an opening meeting and site Induction. Throughout the day the Evaluation Tool was used to interview relevant employees about the mobile bolters. Where possible the actual bolting practices were also observed. The second day was utilised to complete the interviews and then to conduct a closed out meeting.

Observations of the machines selected for the site review were given during the closeout meeting. The presentation focused on the design, operability, maintainability and training of the machines reviewed. Copies of the presentation were made available to the mines.

On completion of the site visit, HMS personnel supplied a Site Visit Satisfaction Survey Form to be completed by the site and returned to HMS. This allowed HMS to monitor the relevance and quality of the site visits, based on feedback from the mines.

5. Project Deliverables

All Project deliverables listed in [Section 4.2 - Project Deliverables](#) have been achieved.

A Project Report provided by HMS to Centennial at each month end tracked the Project progression, including; completed work for the month, planned work for the coming month and any emerging issues.

6. Project Findings

6.1 Interesting General Facts

This Project identified the following general facts associated with strata reinforcement activities in NSW underground coal mines;

- There are 18 different coal seams currently being mined, each seam and surrounding geology presents unique variations in the mining environment in which operators install strata reinforcement
- The dominant roof type is coal followed by sandstone
- The most common working height range is between 2.5 and 3.5 metres
- Most mines utilise a single pass bolt installation method
- There are 155 operational mobile bolting machines across 28 mines
- 63% of these machines are bolter miners with the remaining 37% consisting of a broad range of mobile bolters
- Most mines install support tendons at some point in time
- 45% of the mobile bolting machines were manufactured or overhauled after 2010
- Two manufacturers supply 65% of all mobile bolting machines, with the remaining 35% divided between 12 other suppliers
- Two mining companies have 58% of all mobile bolting machines at their mine sites
- 83% of all mobile bolting machines are operated and maintained by mining companies, the remainder by contractor companies
- The number of mobile bolting machines at an individual mine varies greatly. One mine has 13 mobile bolting machines whilst 2 mines have only 1 mobile bolting machine each. On average there are 5.5 mobile bolting machines per mine.

6.2 MDG 35.1 Timeline

The MDG 35.1 published guideline, titled; *Guideline for Bolting and Drilling Plant in Mines Part 1: Bolting Plant for Strata Support in Underground Coal Mines*, deals with the risks associated with the use of drilling and bolting equipment in coal mines. The Guideline was first published in December 1996 and has undergone several revisions. It was last published in February 2010 with input from the Coal Safety Advisory Committee and the MDG 35.1 Consultative Committee.

6.3 Review of Industry Incident Databases

Incidents contained in the Coal Services database

In the 10 years to 30 June, 2012, 841 injuries were reported to Coal Services for which accompanying narratives indicated that the injury occurred during the operation of a machine mounted bolting rig. These narratives were coded and analysed by HMS for the mechanism of injury.

The most frequent injury mechanisms were; strain, caught between, struck by or striking other, struck by falling coal/ rock, struck by high pressure fluid, struck by drill steel, and slip/ trip/ other.

A summary of the results follow in *Table 3 - Frequency of injury mechanisms related to bolting in NSW underground coal mines for the 10 years to 30 June, 2012.*

Mechanism	#	%
Strain	211	25
Caught between	177	21
Struck by/ striking other	132	16
Struck by coal/ rock	115	14
Struck by fluid	81	9.6
Struck by steel	79	9.4
Slip/ trip/ other	46	5

Table 3 – Frequency of Injury Mechanisms Related to Bolting in NSW Underground Coal Mines for the 10 years to 30 June, 2012

Note: A detailed analysis of Coal Services incident data is contained within Appendix A

Incidents contained in the COMET database

The Department's COMET was established in April 1999. As of December 2012, the database contained 554 records relating to incidents associated with underground coal bolting rigs. Whilst some records relate to injuries, the database also contains records relating to other reportable incidents including; unplanned movements of plant, gas accumulation causing equipment shutdown, fire/ ignition events, defects in explosion protection measures or damage to cables, and escapes of fluid under high pressure which do not strike persons.

The narratives relating to these incidents were coded for the mechanism of injury or nature of non-injury incident. The results are shown in *Table 4 - Frequency of Injury Mechanisms and Incident Types Contained in NSW COMET Database* following.

Injury Mechanism/ Incident type	#	%
All reportable injuries	227	
Struck by fluid	94	41
Struck by steel	35	15
Caught between	28	12
Strain	25	11
Struck by other	23	10
Slip/ trip/ other	15	7
Struck by coal/ rock	7	3
Unplanned movement	106	
Escape of fluid not striking person	100	
Explosion protection defect	76	
Gas accumulation causing shutdown	33	
Fire / ignition	12	

Table 4 - Frequency of Injury Mechanisms and Incident Types Contained in NSW COMET Database

Figure 1 following is a visual presentation of incidents associated with bolting activities (excluding hand-held bolting equipment) contained in the Coal Services and COMET databases respectively.

COMET includes a relatively large number of reports of unplanned movement of bolting machines or bolting rigs (equipment malfunction), escapes of fluid under pressure not striking anyone, and damage to explosion protection. A further large number of incidents are included in which escaping high pressure fluid did strike a person, although very few injuries appear to have resulted. Of the injury reports contained in COMET, “struck by steel” injuries are relatively prevalent, however “strain”, “caught between” and “struck by rock” are somewhat less prevalent than in the injury narratives reported to Coal Services during the same period.

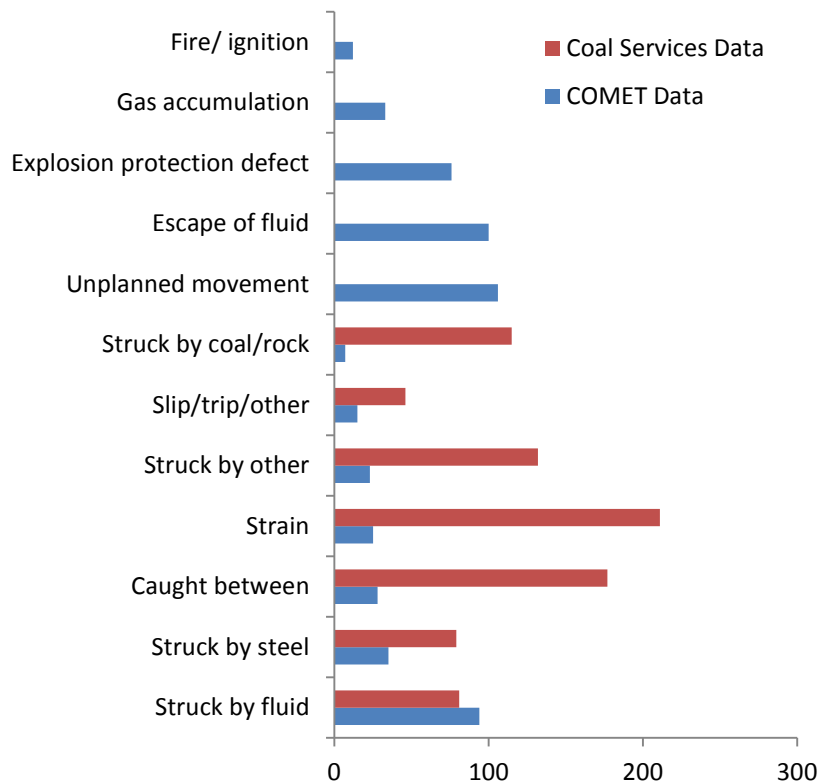


Figure 1 – Comparison of Incidents from COMET and Coal Services Databases

Figure 1 - Comparison of Incidents from Comet and Coal Services Databases highlights the range and type of incidents associated with mobile bolting equipment. The Coal Services database reports injuries of a wide severity range for primarily workers compensation claims. The COMET database reports incidents, with a bias towards higher severity injuries and prescribed incidents, e.g. release of fluid under pressure without injury. Clearly if you viewed either database in isolation of the other you would not have a complete understanding of the incidents that occur whilst operating mobile bolting equipment.

Opportunity for improvement – a review of the database/s requirements and reporting should be undertaken to improve incident analysis and decision making to prevent reoccurrence of incidents. (An example of a further inclusion is, catastrophically deformed/ damaged drill steels).

6.4 Desktop Review of Selected Machines

In September 2013, members of the HMS Project team met with JoyGlobal and Sandvik, being the two principal suppliers of mobile bolting equipment to NSW underground coal mines. At these meetings the manufacturers provided evidence of how their mobile bolting equipment had evolved over time, where their efforts for further health and safety improvements were currently being directed and what the major issues are that require a solution to achieve continued improvement.

Over the last decade the manufacturers have developed and introduced many engineering-based control measures with the aim of minimising harm to people involved in underground mobile bolting processes¹.

These control measures include, but are not be limited to:

- Controls introduced to avoid injury due to the operator's proximity to bolting hazards:
 - Two hand activation required for fast speed functions
 - Two speed rotation units allowing single handed operation of slow speed functions
 - Drill guides, and head plate and gripper jaw arrangements, including 2 step gripper jaw release
 - Improved guarding of controls to prevent unintended operation and guarding to prevent entry into pinch points
 - Reducing fluid injection risk through replacing hosing with piping and placing covers over hosing as far as possible
 - Rib protection for operators
 - Feedback system for automatic adjustment of feed force during drilling – to prevent bent drill steels (introduction currently pending)
 - Improved cutting head spray and dust extraction to reduce dust exposure
 - Improved quality control of drilling consumables
- Self-drilling bolts to reduce the frequency of handling and interactions between operators and rotating equipment
- Controls introduced relating to inadvertent operation of equipment:
 - Shape coding and ensuring consistent directional control-response compatibility to reduce probability of unintended operation caused by selection or direction errors
 - Location of sequence stops adjacent to rib bolting rigs
- Controls introduced to overcome ergonomic hazards:
 - Flatter, larger platforms incorporating stairs and hand rails, reducing slip, trip fall risk
 - Large open working areas (achieved via retractable platforms) provide improved access to drill pots, as does orienting drill pots, or providing slots in the head plate, to reduce reach distance to place steels and bolts

¹ Burgess-Limerick, R. (2010) Reducing injury risks associated with underground coal mining equipment (2nd Ed.) ACARP Project C18012. <http://burgess-limerick.com/download/d10.pdf>

- Improved platform and access way lighting, including on ground behind stairs, particularly through use of LEDs
- Improvements to storage and handling of consumables including supply pods and mesh carriers and mesh handling
- Improved access for maintenance
- Water flow monitoring to individual drill rigs to avert gas ignition (introduction currently pending)
- Blocked steel monitoring

In addition, there have also been technological advancements over this same period with the development and introduction of semi-automatic bolting and electro-hydraulic controls, all of which have safety and health benefits for the operators involved.

With regard to opportunities for continued improvement in the next decade, the ultimate goal remains the development of a tele-operated or automated bolting process where all operators are removed from the drilling platforms thereby eliminating many of the associated hazards. Whilst this appears a longer term goal at present, there are a number of improvements which are achievable in the shorter term, which will continue to mitigate risk of injury and which must remain the focus of research and development.

Principal amongst these are:

- Improved material handling systems for loading and accessing consumables with the aim of reducing manual handling injuries
- Collision avoidance technology to ensure equipment does not operate while persons are in hazardous locations
- Spray-on polymer to replace steel mesh for roof and rib support, or provision of a means of mechanical placement of roof and rib mesh in conjunction with tele-operated bolting
- With each innovation introduced, improved training and assessment to ensure competence, including increased use of virtual simulation
- Rigorous investigation and root cause analysis of incidents and 'near miss' incidents and the dissemination of findings to industry stakeholders who can make a difference

In parallel with the introduction of the control measures mentioned above, both those currently available on the latest machines and those still at the research and development stage, there are a number of issues that should be addressed at an industry level, with input from manufacturers, mine owners and statutory authorities. These include consideration of:

- Retro-fitting of currently available control measures to older machines still in operation, where practicable, within acceptable timeframes
- Increased emphasis on maintainability and reliability of equipment at the design stage, with these issues critical in the ultimate pursuit of tele-operated and automated bolting
- Hazard identification as well as methods of restricting access to Manual/ Maintenance modes in an automatic or semi-automatic operating environment

- Incorporation of Functional Safety principles in the design of mobile bolting equipment. The end user to determine and specify the safety functions and required integrity level of each function. The machine designer to evaluate, design and advise integrity level achieved for each safety function. Re-evaluation of the regulatory requirements with regard to intrinsic safety and SIL/ CAT ratings to establish meaningful guidance for the industry and individual designs
- If, and how, the requirements of cable bolting will be included in the design of fully automated mobile bolting systems of the future
- Consider the compromises and introduced hazards in design and safety when designing a drill rig for both normal encapsulated bolting and cable bolting
- Balancing innovation against the need for system reliability – who bears the risk, and how can the risk be shared by the industry as a whole?
- Industry, manufacturers and government bodies accelerating the application of technology and innovation to improve the health and safety aspects of bolting activities
- What innovations have common applicability and what should be considered for specific applications only and what processes should be used to evaluate the difference?
- How will the industry handle the introduction of various innovations from a change management perspective? Do the present change management plans at each mine cater for the changes in design, maintenance and operational aspects of innovation/ modification? If not they must be amended.
- Maintaining currency of relevant guidelines with regard to latest technology and ensuring these guidelines do not stifle innovation
- Use of currently available hazard evaluation for improving design and documenting improvements for communication to purchasers e.g. Operability and Maintainability Analysis Technique (“OMAT”), Design Evaluation for Equipment Procurement Process (“EDEEP”),² Earth Moving Equipment Safety Round Table (“EMESRT”)
- Maximising interaction with industry working groups and bodies conducting research and development on an international basis

² Burgess-Limerick, R. Joy, J., Cooke, T. & Horberry, T. (2012). EDEEP - An innovative process for improving the safety of mining equipment. [Minerals 2, 272-282](http://www.mdpi.com/2075-163X/2/4/272). <http://www.mdpi.com/2075-163X/2/4/272>

6.5 Mine Site Review of Selected Machines

HMS visited all 28 operational NSW underground coal mines and conducted detailed reviews of a selection of mobile bolting machines at each mine, using the Evaluation Tool developed specifically for this Undertaking and approved by the Undertaking Technical Working Group. One machine selected being relatively new and the other machine selected being one of the older machines that are still in service. The sample of machines reviewed represents approximately one third of all machines currently in service.

The positions of personnel interviewed at each mine site included;

- Production Manager
- Manager of Mechanical Engineering
- Manager of Electrical Engineering
- Mining Supervisor
- Operator
- Maintenance Supervisor
- Maintainer
- Safety/ Training professional

The underground visits occurred on both production and maintenance shifts which was very helpful in understanding the activities carried out by both machine operators as well as machine maintainers.

The Evaluation Tool consisted of questions relating to the following life cycle elements;

- Design
- Operability
- Maintainability
- Training

Following is a summary of the key learnings from the 28 mine site visits;

- Most sites indicated a **design risk assessment** had been carried out on mobile bolting machines chosen for review, although in some cases this took the form of a generic risk assessment relevant to the type of machine, without specific consultation with site as the “end user”. In some other cases, the risk assessments provided were essentially operational risk assessments carried out following machine modifications. Where design risk assessments had been carried out, only a few sites could confirm that these included consideration of the hazards associated with poor storage of drill steels and their interaction with the mobile bolting machines.

Opportunity for improvement – Manufacturers should supplement existing design risk assessments for the particular model of machine with additional design risk assessment to cover client-specific features of the machine prior to construction.

- The majority of sites reported that a **design modifications risk assessment** is carried out prior to any **changes** being made to the design of one of the roof bolters or changes in the operation of the roof bolter. This would normally be initiated by the site's Change Management procedure. In one case, where the machine was hired, this was seen as the responsibility of the machine owner rather than the Operator.

Opportunity for improvement – where there is a change in the application, method of operation or use of equipment an operational risk assessment should be conducted. If design changes are recommended by the operational risk assessment they should be included in a design risk assessment undertaken by the person or persons responsible for the change, potentially the manufacturer or the designer of the change.

- Generally, the design of the mobile bolting machines reviewed allowed **reasonable access** to all parts that require adjustment, cleaning or service.
- In most cases provision has been made to **secure all materials** associated with the bolting and drilling activities. Exceptions to this were generally a lack of secure storage of drill steels in close proximity to the bolters – such as retaining clips or magnetic holders, and the storage of mesh and mesh modules in the rib outbye of the mobile bolting machine.

Opportunity for improvement – manufacturers should improve design of storage of drill steels in close proximity to bolters.

- **Loading of consumable materials** such as drills, bolts, chemicals, plates etc. was observed to involve manual handling in approximately 50% of the machines reviewed, with the remainder utilising systems involving pre-loaded cassettes positioned by the use of LHD equipment.
- Generally, the design of the mobile bolting machines reviewed allowed **access to consumables and tools** between the steps of drilling and bolting activities without having to leave the work area. An exception to this was the storage of cable bolts outbye of the mobile bolting machine.
- **Safe guarding systems** as suggested by MDG 35.1 were in place on the majority of mobile bolting machines. These included physical guarding of hydraulic hoses and control levers, two handed operation, reduced speed for one hand operation, separation of control handles, controlled thrust force, pinch point deflectors and preventers.
 - In most cases, drill rotation and drill feed **manual controls** are set up such that these controls cannot be operated by one hand. This was achieved by the use of separation plates between the feed and rotation control levers (roof bolters), or the positioning of these levers at opposite ends of the valve bank (rib bolters). There were several examples, however, where two handed operation was either not part of the bolter control design, or could be fairly easily defeated. These examples included a bolter miner where the roof bolter's feed and rotation controls could both be operated one handed at full speed, another where the rib bolters could be operated one handed at full speed and a multi bolter where all functions could be operated one handed at full speed.
 - In the case of **automatic control**, most bolting rigs reviewed were set up such that initiation of automatic drilling was only possible with a safe guarding system

whereby the operator is clear of rotating or moving parts. On some bolters this involved the operation of three (3) levers in sequence, with an “auto cancel” or “dead man” control lever separated from the feed and rotation controls. However, inadequate segregation of the “auto cancel” control lever, coupled with pilot operation of the auto rotation function on a commonly used valve bank means that drilling can be initiated in automatic mode with one hand, on bolters equipped with this particular valve bank.

Opportunity for improvement – Manually controlled valve banks should be standardised to comply with MDG35.1 as far as practicable to allow for two handed operation and reduce speed safe guards.

- Hoses were mostly well guarded with a **double sleeving** of Kevlar material and, in many cases, an additional layer of spiral wrap and/ or poly guarding. There were also several examples of the use of a Bretby arrangement to protect and bundle hoses, as well as steel or poly guards around drill motor fittings and control panels. An excellent safety initiative to assist identification of fluid injection in a person has been initiated by one mine by the use of an additive in the hydraulic oil called “Fluid Safe” which enables identification of hydraulic fluid under the skin through the use of a blue light.
- **Presence devices and pressure mats** interlocked with bolter operation were, with one exception, not installed.

Opportunity for improvement – generally the industry wish to review the relevance and value of this requirement.

- Most bolting rigs reviewed were designed for **single person operation**; with the exception of air track and single boom electric operated mobile bolters, and QDS bolters, which are normally operated by two people, due to the controls being located remotely from the bolter.
- Almost unanimously amongst the machines reviewed, a dolly was required for bolt installation and tightening. One mine stated that it did have a **chuck that suited both drilling and bolting** functions without using a dolly.

Opportunity for improvement – Trial chucks suited to both drilling and bolting to lessen interaction of operator with the drill motor.

- Most machines reviewed incorporated **gripper jaws and head plates** with the roof bolters to secure and guide the drill steel, with load holding devices part of the gripper jaws to prevent the drill steel or bolt falling from the hole. Drill steels were also, in most cases, **positively engaged** in the drill motor chuck by a twist-lock mechanism, to prevent the same hazard, although a number of operators stated that the drill steel could disengage if rotation ceases on withdrawing from the hole. Gripper jaws and head plates were generally not incorporated in the rib bolters.

- Only a few mines have installed **water flow monitoring** on each drill rig. At this point, most sites have only installed water flow monitoring on the incoming supply to each mobile machine, although some have blocked steel monitoring.

Opportunity for improvement – Update the Guideline to recognise that both blocked steel drill monitoring and water flow monitoring are a means of reducing methane ignition.

- In most cases, the bolter controls were located at the operator's work station and within the operator's reach envelope such that the operator does not have to **bend or stretch excessively**, with the exception of roof cavities. A number of bolter miners had a step installed beside the bolter to assist reaching higher roof.
- Some site personnel indicated that the design of the roof bolters, in either a north-south or east-west configuration, can greatly affect the operator's reach envelope and therefore susceptibility to strain injuries. There were some examples of outer rig drill motors (east-west) being relocated to the inside of the mast to reduce stretching of the operator.

Opportunity for improvement – Operators should liaise with manufacturers to provide optimum positioning of bolting rigs to enhance safety and ergonomics for operators and maintenance personnel.

- In all machines reviewed, bolting controls were positioned so that the **operator is located** under a permanently supported roof, or otherwise under an operator protection system (TRS) which provides an equivalent level of safety.
- In almost all cases, **emergency stop facilities** were installed in close proximity to each bolting rig control station and each machine tramming station. One exception found was in regard to an LHD used to carry a QDS man basket, where there was no E-stop located in the LHD driver's cabin.
- In most instances, the primary bolting control levers were **shaped differently** for the different functions (rotation, feed, timber jack). Exceptions to this rule were in the case of newer bolting rigs incorporating electro-hydraulic controls where buttons are utilised instead of levers. In one case, there was no differentiation except for labelling; whilst in another case raised guards were employed around the three primary bolting control buttons, with each guard shaped differently.
- Almost exclusively, the primary control handles were **not keyed** to prevent swapping of handles during maintenance activities, being simple screwed attachments. Most sites considered keying of control handles impractical in that the handles could still be swapped in combination with additional segments of the valve bank. However some sites included a description of which shaped handle was to be fitted to each of the three primary control levers in their inspection/ maintenance work orders.

- In all machines reviewed, **direction of operation** of controls was not consistent with the MDG 35.1 guidelines, with most control levers moving in the vertical plane only. The guideline also makes no allowance for newer bolting rigs incorporating electro-hydraulic controls, where buttons are utilised instead of levers.

Opportunity for improvement – Update MDG 35.1 to include the use of electro-hydraulic controls.

- In general, **labelling** of primary and secondary controls was not strictly in accordance with the guideline, with minor wording differences on most machines. Examples here are the use of terms such as “Up/ Down” or “Extend/ Retract” instead of “Advance/ Retract” in reference to feed control.
- **Temporary roof support (“TRS”)** systems were in place on approximately 60% of the mobile bolting machines reviewed. Where no TRS system was present, the machine was generally an air track or mobile bolter being used for secondary support in outbye areas of the mine although some bolter miners didn’t have TRS systems installed. In these cases, the design of the bolters relied on the operator being protected by the controls located under supported roof only (following a risk assessment into not using a TRS system).
 - In many cases, it could not be determined if the TRS was designed in accordance with MDG 35.1 guidelines, as the manufacturer had not supplied details with regard to the rated design capacity for vertical loading, or the axial and side loading associated with possible angles of inclination of the TRS. In most cases, the TRSs (nor the controls) were not labelled with the rated design load and yield capacity. In some cases, the TRS was found not to comply with the guideline requirement that tramming should be prevented when the TRS is set to the roof.
- **Rib protection shields** were in place on many of the mobile bolting machines reviewed. These consisted of a variety of designs with a corresponding range in the degree of protection provided to the operator. Similarly to the TRS systems, the manufacturer had generally not supplied design details and most shields were not labelled with their design capacity.

Opportunity for improvement – Ensure the manufacturer designs TRS and rib protection shields in accordance with the guideline requirements.

- **Protective guards** or **protective canopies** to prevent falling material injuring the operator were generally not included in the machine design. Of the small number of canopies sighted, only one certificate of compliance was sighted.
- Where **platforms** were incorporated on the mobile bolting machine, approximately half had adequate edge protection consisting of toe plates and guard rails.
- Adequate area lighting was installed on most machines.
- Individual hydraulic **isolation** valves were provided on many bolting rigs. Where the manufacturer does not provide individual isolation valves on bolting rigs, manual drill rig controls have hydraulic sequence stop valves. However, most mines have introduced a standard which required whole of machine isolation prior to conducting repairs and maintenance in any area of the machine, including the bolting rigs. Verification can be achieved by function testing and checking of pressure gauges.

- A comprehensive **noise survey** of the drilling or bolting equipment had been conducted and incorporated in the design documentation for only some of the machines reviewed. However, all sites did provide hearing protection to all persons and enforce its use during drilling and bolting activities.
- In many cases a **commissioning plan** was developed and used for introduction of the mobile bolting equipment on site. Generally the manufacturer provided a commissioning plan which was carried out either on site, or as part of the exit audit before the machine left the manufacturer's factory. Many mines conducted their own commissioning checks as part of the "Introduction to Site" process.
- **Safe standing/ No Go Zones** for tramming of the mobile bolting machines were enforced at all sites and well understood by all personnel interviewed.
- In most cases, a **Safety File** existed at the mine for each mobile bolting machine reviewed, usually based on documents provided by the manufacturer. The safety files mostly did not contain all the information suggested by the guideline, however this information was generally to be found elsewhere in the site's paper or electronic files. Examples of this are design specifications and performance conditions (included in the Tender/ Contract documentation), and maintenance, safety and training records (generally kept in electronic format).

Opportunity for improvement – Where required information is kept separately, ensure the safety file references its location.

The safety files generally did not contain detailed information on the identification and assessment of **safety critical functions** on the bolting systems of the respective machines, with only a few sites able to provide determined SIL and/ or CAT levels for these functions. There appeared to be poor communication and documentation in this area.

Opportunity for improvement – The design/supply/operate/modify process should be reviewed to determine the safety critical system requirements and responsibilities for the life cycle of a piece of equipment.

- **Operational risk assessments** were found to have been carried out on most of the mobile bolting machines reviewed. Most, however, did not include assessing the potential for energy transfer from falling or ejected objects (resulting from a fall of ground striking plant or equipment in the work environment). These risk assessments were generally not retained in the machine's safety file, but stored electronically on site.
 - Most sites reported that operational risk assessments were conducted on modifications to bolters before putting the machine into operation or when variations in use, conditions or environment could change the risk. These risk assessments were initiated at most sites by the Change Management procedure, with all personnel notified of any changes through a variety of mediums such as tool box talks and start of shift meetings.
- In many cases, the operator had reviewed existing **Job Safety Analyses** ("JSA's") or conducted JSA's relating to roof support practices with particular regard to the position of people, equipment and materials and their exposure to impact from falling ground, either directly or indirectly.

- At most sites, operators and maintenance personnel conduct **pre-start inspections** of the bolters and **SLAMS/ Take 5's** or similar before operating, inspecting or carrying out maintenance on the bolters. Regular observations are also carried out by supervisors (Safe Act Observations, Critical Task Observations etc) and some sites reported “peer on peer” inspections.
 - Most sites had a **“Near Miss” reporting system** in place as part of their overall Incident reporting system, with all relevant personnel informed of the results of any investigations.
 - The majority of sites reported that all strata support and drilling activities are carried out under the direction of a **competent supervisor** (Mining Supervisors) during inspections as the operators are appointed/ authorised to operate the bolters unsupervised (except when supervised during training), with drilling and bolting activities **audited, monitored and reviewed** at regular intervals through a variety of methods including site audits, supplier audits, pull testing etc.
 - Most sites had a **Fatigue Policy** in place with supervisors regularly looking for signs of fatigue in personnel.
 - Most sites have a **maintenance and inspection scheme** for each mobile bolter which was work order driven with the work orders requiring **full energy isolation** as the first step in maintenance activities.
 - Most sites reported that repair and maintenance procedures have regard for the requirements of MDG41 - Guideline for Fluid Power Safety at Mines (“MDG41”) in that their purchasing standards require the purchase of MDG41 compliant hoses and fittings only.
 - Most sites reported that all personnel who are required to operate, inspect or maintain the bolters had been trained in the use and maintenance of the bolters, with training in most cases supplied initially by the manufacturer and further training provided by site appointed trainers and assessors. Fitters were expected to receive the full operators training at most mines as well as complete additional training in the inspection, maintenance and repair of the bolters. Training included energy isolation in all cases.
 - Training required theory/ assessment, issue of Learners Permit, training under supervision of an appointed trainer, competency assessment then appointment/ authorisation to operate the bolters unsupervised.
 - Most sites included as part of training, **potential injury mechanisms** such as inadvertent drill rig operation, entanglement of hands with rotating drill steel and roof mesh and rotating/ sliding parts of the drill rig as well as escape of fluid. At quite a number of sites, this could not be verified in training documents.
- Opportunity for improvement – mine sites should improve the administration of training documentation and records related to this “topic”. Where no records exist, personnel should undergo training as soon as practicable.*
- In most cases, training included challenge testing and re-assessment at regular intervals, varying from 2 – 3 years.

7. Project Key Performance Indicator Results

The Project delivery team achieved or exceeded the Project KPIs. The actual Project KPI results follow in *Table 5 – Actual Project KPI Results*.

KPI Description	Planned	Actual
Strong participation of NSW underground coal mines	>80% of mines	100% of mines
Positive Satisfaction Survey results from participating sites	>4 average rating	4.2
Project completed within timeline	Zero over-run	Zero over-run
Acceptance of findings by Steering Committee	>90%	
Project Health, Safety, and Environmental Incidents	Zero	Zero

Table 5 – Actual Project KPI Results

APPENDIX A

Review of Coal Services Incident Data

In the 10 years to 30 June 2012, a total of 841 injuries were reported to Coal Services for which accompanying narrative indicated that the injury occurred during the operation of a machine mounted bolting rig.

A summary of these incidents sorted by injury mechanism, as taken from the database, follows:

(Note; the information has not been modified by HMS other than to remove reference to a mine and/or machine).

Strain injuries, typically of the shoulder and back, are associated with the manual tasks injury risk factors (forceful exertions, awkward postures, and repetition) inherent in handling drill steels, bolts, dolly during the bolting process. For example:

- While installing roof bolts he reached out to fit a bolt into dolly straining his r/chest muscles
- While on drilling machine pulling drill steel out of the roof he felt pain in his r/shoulder
- While roof bolting on the c/miner he pulled a 7' drill steel which was stuck in the chuck straining his r/shoulder - rotator cuff injury
- While bolting the roof steel became stuck when pulling jammed drill steel from roof he strained his r/shoulder
- While on c/miner roof bolter putting up a roof bolt he strained his r/shoulder
- While reaching around timber jack on hydraulic bolting rig on c/miner when installing roof support at the coal face he strained his upper back
- While bolting roof in low area to extract drill steel from roof had to shake & pull on steel to get it past drill pod straining his lower back
- While operating a roof bolter he was bent over reaching to remove a drill steel from the chuck straining his lower back
- While operating right rig on fletcher bolter when he reached out to insert a rib bolt in a hole he tore r/chest muscle

Caught between/ struck by injuries are commonly associated with errors in the operation of bolting controls. These errors may be categorised as:

Inadvertent operation e.g.:

- While removing drill steel from fletcher hit isolation bar & put fingers near the jaws when he accidentally pushed on the lever jamming his r/index & middle fingers fracturing distal phalanx

- While changing drill steel the operator of bolter turned on the rotation of the drill which caught his glove & pulled hand around steel ripping glove off spraining r/hand & lower back
- While using c/miner mounted rib bolter the steel jammed in the hole he tried to free it with a shifter when lamp lead caught control lever which operated timber jack causing bruising to l/hand & fracture l/5th finger
- While removing 7' drill steel his battery pouch caught a lever which lowered the timber jack bending the drill steel forcing his r/middle & ring fingers in the mast causing laceration
- While using c/miner removing dolly from drill chuck battery struck rotation lever causing dolly to spin crushing his l/middle finger between long dolly & timber jack fracturing distal phalanx
- While removing drill steel from drill rig when sleeve of jacket came in contact with feed lever causing drill steel to hit timber jack smashing his l/thumb between steel & rig - bruise
- While undoing drill steels using 2 shifters & dollies when his light cord activated the bottom rotation levers bruising his l/shoulder

Selection errors e.g.:

- While rib bolting fitting the dolly to a bolt he pulled the lever to send the timber jack out but operated the retraction ram valve squashing his l/thumb - bruise
- While operating rb installing roof bolts he placed his l/hand on the dolly to remove it he pulled the wrong lever jamming his l/ring finger - crush injury
- While roof bolting putting roof bolt to the roof he pulled the wrong lever which brought the timber jack down trapping his r/arm between timber jack & manifold lacerating r/forearm & wrist
- While roof bolting and collaring the hole he pulled the rotation handle rather than the feed handle which caused the steel to rotate. His glove got caught on the drill steel and ripped causing a fracture to his left little finger
- While roof bolting he pulled the wrong lever causing the drill steel to hit his left hand causing a laceration
- While operating rib borer guiding 6' steel into rib hit wrong lever crushing his l/hand between timber jack & bolting rig
- While putting rib support in the drill steel stuck & pulled out of chuck as he reached back to fine tune alignment of drill rod he pulled the wrong lever pushing timber jack out crushing l/hand against the rib
- While extending c/miner platform he pulled the diversion lever to push platform out the rib bolter came down jamming his l/foot causing fracture to l/5th toe

- While attempting to spin off rib bolt he inserted dolly into chuck he pushed the handle in the wrong direction the dolly fell out hitting & bruising his r/big toe
- While operating lhs walk through bolter when using 12" shifter to dismantle rope drills he pulled wrong handle to rotate chuck & spanner hit his cheek causing laceration - stitches
- While roof bolting his l/arm was entangled between steel - rib mesh & a drill steel causing amputation to his l/forearm (the subsequent investigation revealed this to be a selection error)

Direction errors e.g.:

- While installing roof bolt steel he went to raise timber jack pulling handle the wrong way pinning his r/arm between timber jack & top of rig grazing his r/forearm
- He was installing roof bolt, bolt got caught on mesh. He went to lower drill but accidentally raised it bending the bolt and crushing his left hand between the roof bolt and rib causing a laceration to the left index finger
- While on c/miner rig 6' hole drill steel became bogged he lowered the chuck operated feed handle in the wrong direction bending the drill squashing his r/thumb - fracture & nail bed injury
- While roof bolting on side of c/miner undoing an extension steel with shifter he accidentally rotated the steel the wrong way shifter spun back & struck his r/hand-bruise

Operation while in hazardous position e.g.:

- While bolting on c/m his arm was resting on platform of drill rig when he attempted to move drill rig down to clear mesh he moved timber jack down squashing his l/forearm causing laceration
- While being trained on fletcher roof bolter trying to get 4'drill steel to start hole in the roof when he activated the rotation with r/hand his glove was wrapped around the steel lacerating his l/little finger - stitches
- While rib bolting he used his hand to steady the drill when his glove became caught straining his left thumb
- While roof bolting, held the drill steel with his l/hand to guide the steel he rotated the steel slowly with the rotation lever causing glove to wrap around the steel pulling his over - sprain
- Miner was operating the drill rig when he removed chuck from drill pod and rested his left hand on second stage of drill carrier then operated feed up resulting in his left hand being jammed causing soft tissue injury
- During drilling operations he put his hand on the drill rig to balance himself as the drill mast was coming down & caught his r/hand momentarily on the plate - crush injury r/ring & middle fingers
- While operating rib bolter on c/miner he crushed his r/forearm between the timber jack & bolter

- While attempting to insert drill steel into chuck of machine his r/hand & thumb was squashed when gripper jaws of fletcher bolter closed on his hand causing crushing injury
- While drilling hole for roof bolt installation drill steel bowed between roof & drill chuck crushing l/middle finger causing partial amputation
- While roof bolting installing chemical into roof & guiding roof bolt into hole his l/forearm got jammed between top of timber jack & bolting rig fracturing remedial shaft
- While holding mesh pod on the c/m rig with l/hand he raised the timber jack with r/hand jamming his l/ring finger between the roof & mesh sheets - fracture
- While operating left hand side fletcher bolter when he went to operate the jaw clamps to hold drill steel he caught his/hand in clam jaws of bolter causing crush injury to r4th & 5th finger
- While operating the drill rig guiding dolly onto bolt he brought the drill pod up and caught his finger between the drill pod and the timber jack lacerating his right hand little finger.

Sometimes the person in the hazardous position was not the operator.

- While bolting using hydraulic rigs on c/miner he climbed upon head platform to pull mesh back when a co-worker lowered the rig drill pot the second stage came down to his r/foot causing crush injury
- While assisting with installation of rib dowels he had inserted the chemical & rib dowel co-worker believed his hand was out of the way when he operated the rig catching his l/hand between rig & rib-laceration
- While discussing the bolting operation with his crew he placed his right hand on the right rib borer on the roof bolter. As the borer retracted it struck his right hand causing a laceration to the fingers on his right hand
- While doing electrical inspections placed his hand on the back end of the rib bolter, the rib bolter operator retracted the drill chuck this resulted in crushing the right little finger causing a laceration to the right little finger

The most common struck by mechanisms involved **coal/ rock** e.g.:

- While bolting on c/miner a piece of stone fell from roof hitting his head spraining his neck
- Whilst he was installing a roof bolt on the miner the rib blew out and struck him as he moved away from it he was knocked to the ground causing him to land on the timber jack
- He was about to pin up a sheet of mesh when he turned to get the end of the mesh the unsupported roof collapsed and a slab of stone bounced off the drill rig and struck his back lower left leg resulting in a contusion to the left calf

Fluid e.g.:


- While roof bolting on the c/miner the rotation hose burst spraying oil into his left eye
- While operating a drill rig one of the hydraulic hoses burst and he was hit in the face with hydraulic fluid
- While operating the bolting drill rig the drill rig hose split causing hydraulic oil to spray in his face causing foreign body to the left eye
- He was tensioning the roof bolt nut with side bolting rig when the rotation hose burst and he was sprayed with hydraulic oil to the face possibly causing a fluid injection
- While bolting a hydraulic ruptured resulting in hydraulic oil to escape under pressure. The oil struck him on the right upper arm causing a foreign body to the upper right arm
- Whilst he was bolting on b rig of joy c/miner main pressure hose burst and sprayed him in the groin area with hydraulic fluid causing him extreme pain-contusion
- While roof bolting a hydraulic hose burst spraying hydraulic oil on his back & legs - suspected high pressure fluid injection
- While operating roof bolting machine on c/miner a hydraulic oil hose burst spraying him in the face with hydraulic oil causing corneal abrasion to his eyes

Or Drill steels e.g.:

- Whilst positioning drill steel to drill roof the drill steel came into contact with the roof causing the drill to spring out of the chuck and strike him causing a fracture to his right arm
- While roof bolting the drill steel got stuck in the hole. As he attempted to remove the steel it fell striking him on the face. This caused an abrasion to his upper lip left cheek and left forearm and a strain to his neck
- While drilling he withdrew the steel bolt, when he lowered the timber jack, it caught the 6' steel which bent and flung out hitting him causing laceration to his left cheek and strain to left forearm
- When roof bolting a 6' steel fell from the roof lacerating his r/hand
- While drilling top hole for rib support drill steel became wrapped around the rib mesh he tried to free it from the mesh when drill got jammed & came out of dolly causing steel to hit his face
- While drilling installing 7' steels he could not release steel from chock he went to push steel back up it bent when pushing retract lever the steel spun hitting & bruising his r/hand
- While roof bolting using c/m mounted rigs turned around to get a bolt & chemical when he turned back drilling finished chuck came down seconds later steel came out striking his l/foot

APPENDIX B

Review Evaluation Tool

Mining Workplace Agreed Undertaking Project Evaluation Tool									
Manager of Mechanical Engineering	Manager of Electrical Engineering	Operators / Maintenance Personnel	Mining Supervisors	Development "Superintendent"	Safety Training Coordinator	LIFECYCLE	QUESTIONS		
✓						Design	Has a design risk assessment been conducted (Sections 2.3.4 and 3.2.2)?		
✓						Design		Did this design risk assessment include unintended behaviour of the machine operator or reasonably foreseeable misuse of the machine, including behaviour resulting from not returning drill steels to the storage pod at the rear, or other locations, of the mobile bolter?	
✓		✓				Design		Does the design of the system allow reasonable access to all parts that require adjustment, cleaning or service (Section 3.2.1)?	
		✓				Design		Has provision been made to secure all loads associated with the bolting and drilling activities, such as materials storage (Section 3.2.1)?	

✓		✓				Design		Has a system for the safe handling and loading of consumable materials such as: drills, bolts, chemicals, plates, etc. been specified (Section 3.2.1) (Note; Manual loading of bolting supplies does not constitute a "safe system")?	
		✓				Design		Can operators access consumables and tools between the steps of drilling and bolting activities without having to leave the work area? The handling system should minimise reach distance and exposure to hazards where practicable.	
✓						Design	Is a design modifications risk assessment carried out prior to any changes being made to the design of one of the roof bolters or changes in the operation of the roof bolter (Sections 2.7 and 3.2.2.1)?		
✓						Design	Are the following safe guarding systems in place (Section 3.3):	a) Physical guards (including prevention of inadvertent operation, struck by fluids from burst hoses, guarding of control handles)	
✓					Design	b) Speed of operation of bolter components (including reduced speed when using one handed control)			
✓					Design	c) two handed operation (including prevention of inadvertent operation, selection errors)			
✓					Design	d) control handles sufficiently separated to prevent inadvertent operation			
✓					Design	e) sensitive protective devices such as presence devices, pressure mats, etc. (Is interlocked sensing of a person's body set up so the rig is prevented from operating when a dangerous situation exists)			

✓						Design		f) controlled or reduced force (thrust or rotation) (e.g. automatic drill thrust and penetration rate control to minimise drill rods bending/breaking/becoming jammed)	
✓						Design		g) pinch point preventers (e.g. buffers, spacer stops or bump stops)	
✓						Design		h) deflectors from pinch / shear points; and	
✓						Design		i) other forms of protective devices e.g. self clearing mechanisms and use of non metallic pliable material,	
✓						Design		j) double sleeving / guarding of relevant hoses	
✓						Design	Is each individual bolting rig designed for single person operation (Section 3.4.2)?		
✓		✓				Design	Is a chuck that suits both drilling and bolting functions without using a bolt tightening device (dolly) being used where practicable (Section 3.4.3)?		
✓		✓				Design	Is a means of securing both the rotating drilling steel and the bolt tightening device (dolly) in the drill head provided (Section 3.4.3)?		
✓	<input type="checkbox"/>					Design	Where there is a risk of gas ignition with wet drilling in an automatic mode, has water flow monitoring been provided on each drill rig (Section 3.4.4)?		
✓		✓				Design	Has a system of guiding the drill steel, such as head plates, been incorporated (Section 3.4.5)?		
✓		✓				Design	Are Gripper Jaws to hold the drill steel or cable bolt included in the head plate where extension drills and cable bolts are used (Section 3.4.6)?		

✓		✓			✓	Design	Is a load holding device provided on the gripper jaw function in order to prevent the drill/bolt falling (Section 3.4.6)?		
✓		✓				Design	Are bolting controls positioned so that the operator is located under a permanently supported roof or otherwise under an operator protection system which provides an equivalent level of safety (Section 3.5.1)?		
✓		✓				Design	Are bolting controls located at each operators work station and within the operators reach envelope(Section 3.5.1 and 3.5.6.3)?		
		✓				Design	Does the work area require the operator to bend or stretch to access bolt hole (The operator should be able to reach the drill head while in a normal upright position and without flexing the shoulder - a <i>photo would be helpful here</i>)?		
	✓					Design	Are emergency stop facilities provided at –	a) each tramming station.	
	✓					Design		b) within reach of each bolting rig control station (Section 3.5.3)?	
✓						Design	Are primary bolting control levers shaped differently for different functions (e.g.. Rotation control - 3 balls in line, Feed control - round disc, timber jack control - rectangle) (Section 3.5.8)?		
✓		✓			✓	Design	Are handles keyed to prevent shapes being swapped during maintenance?		
✓						Design	Are the direction of operation of controls consistent with 3.5.6.2?		
✓		✓				Design	Are drill rotation and drill feed manual controls set up such that these controls cannot be operated by one hand, unless otherwise protected with a safe guarding system (Section 3.5.9)?		

✓		✓				Design	To initiate either automatic or semi automatic functions is a safe guarding system provided so that the operator is clear of rotating or moving parts? This system may include two separate controls activated in a particular order.		
✓		✓				Design	Where provided, are these controls segregated so they can not be operated simultaneously by one hand (Section 3.5.10)?		
✓		✓				Design	Is the drill steel positively engaged in the drill motor chuck as it is retracted from the roof? (Section 3.5.10)		
✓		✓				Design	Are the primary and secondary controls labelled in accordance with Sections 3.5.14 and 3.5.15?		
✓		✓				Design	Is there a temporary roof support (TRS) system in place (Section 3.6.4)? This TRS does not include the roof bolter timber jack unless it is specifically designed for the function		
✓						Design	Is the TRS system designed in accordance with the requirements of Section 3.6.4?		
✓		✓				Design	Are rib protection shields being used as a risk control (Section 3.6.5)?		
✓						Design	Is the rib protection shield designed in accordance with the requirements of Section 3.6.5?		
✓		✓				Design	Are operator protective guards / protective canopies being used as a risk control to prevent small, falling material from hitting and injuring the operator during or from the strata support process (Section 3.6.6)?		
✓						Design	Is the operator protective canopy designed in accordance with the requirements of Section 3.6.7?		
✓		✓				Design	If a platform is in use, is there edge protection?		

	✓					Design	Is illumination provided on the platform?		
✓		✓				Design	Can the bolting rigs be isolated?		
✓		✓				Design	Can the isolation of the bolting rigs be verified?		
✓						Design	Has a comprehensive noise survey of the drilling or bolting plant been conducted and be incorporated in the design documentation (Section 3.8)?		
✓						Design	Have appropriate control measures been taken if exposure to noise at the operator's station exceeds – a) an 8-hour equivalent continuous sound pressure level, LAeq,8h, of 85 dB(A), or b) peak levels of 140 dB(C) weighted (Section 3.8)?		
✓	✓					Commissioning	Was a commissioning plan developed and used during the commissioning of the bolting plant (Section 4.2)?		
✓	✓					Maintenance	Is there a maintenance and inspection scheme for each roof bolter (Section 6.2)?		
✓		✓				Maintenance	Do repair and maintenance procedures identify full energy isolation as the first step?		
✓						Maintenance	Do repair and maintenance procedures have regard for the requirements of MDG41?		
✓		✓	✓			Operation	Are safe standing zones or operator location while tramming the plant specified (Section 3.10.7)?		
✓	✓					Operation	Does a Safety File exist for each mobile bolter / bolter miner?		
✓	✓					Design	Does the Safety File contain the required information specified by MDG35.1 (Sections 2.5, 3.12.1) for each roof bolter?	a) Design specifications, performance and conditions as specified in clause 3.1.	

✓	✓					Design	<p>Has an operational risk assessment been conducted for each bolter (Sections 2.3.4 and 5.1.1)?</p>	b) Design documentation as specified in clause 3.12.	
✓	✓					Design		c) Hazard identification and risk assessment documents, including design risk assessment, operational risk assessment	
✓	✓					Design		d) Risk control methods.	
✓	✓					Design		<p>e) Identification of all safety critical systems and their safety category or integrity level.</p>	a) Have all of the safety critical functions required for the safe use of the bolting plant been identified and documented by the designer?
✓	✓					Design			b) Has the minimum safety integrity level (SIL) for each safety critical function been determined?
✓	✓					Design			c) Has an appropriate recognised standard such as AS 4024:1501 and 4024:1502, or AS/IEC 62061, or AS/IEC 61508 or other similar standards or rating system been used to validate the safety level?
✓	✓					Design			d) Has the SIL level been achieved in the design for each safety critical function?
✓	✓					Operation		f) Consultation records (including whether experienced operators and maintainers were involved in the risk assessments)?	
✓	✓			✓		Operation			

✓				✓		Operation		Did the operational risk assessment include assessing the potential for energy transfer from falling or ejected objects (resulting from a fall of ground striking plant or equipment in the work environment) in the design of safe working systems?	
✓						Operation		Is a copy of this operational risk assessment retained in the respective roof bolter's Safety File (Section 2.5)?	
✓				✓		Operation		Has the operator reviewed existing JSA's or conducted JSA's relating to roof support practices with particular regard to the position of people, equipment and materials and their exposure to impact from falling ground, either directly or indirectly	
✓				✓		Operation		Is an operational risk assessment conducted on the modified bolter before putting the machine into operation or when variations in use, conditions or environment could change the risk (Sections 2.3.4, 2.7 and 5.1.1)?	
✓				✓		Operation		Have all necessary personnel been notified of these changes to the design of the roof bolter or to the operations of the roof bolter (Section 2.4)?	
		✓				Operation	Do the operators conduct pre-start inspections of the bolters (Section 5.3)?		
		✓			✓	Operation	Do operators / maintenance personnel conduct SLAMS / Take 5 assessments before operating, inspecting or carrying out maintenance on the bolter?		
✓			✓	✓	✓	Operation	Are regular observations made by Supervisors of personnel operating / inspecting or maintaining the roof bolters (e.g. Safe Act Observations, Safety Observations, Strive for L.I.F.E. Walks) that check for safe work practices, compliance and fatigue?		
			✓	✓	✓	Operation	Is there a near miss reporting process for roof bolter operations / maintenance / inspections?		

					✓	Operation	Are relevant personnel informed of these roof bolting accident / incident / near misses and the results of the investigations?		
			✓	✓		Operation	On the bolting machine are all strata support and drilling activities carried out under the direction of a competent supervisor (Section 5.1.4)?		
				✓	✓	Operation	Are the drilling and bolting activities audited, monitored and reviewed at regular intervals (Section 5.1.5)?		
					✓	Operation	Is there a fatigue policy in place at the mine?		
✓	✓		✓	✓		Operation	Do Supervisors look for signs of fatigue in operators during their observations of personnel working with the bolting plant?		
			✓	✓		Training	Have all personnel who are required to operate, inspect or maintain the roof bolters been trained in the use and maintenance of the bolters (Sections 2.3.6 and 5.1.3)?		
					✓	Training	Does this training include the energy isolation practices prior to repairing or maintaining the bolting plant?		
					✓	Training	Was potential injury mechanisms and site/task risk assessment principles included in this training regarding the support system?		

		✓			✓	Training	Have persons involved with the installation of roof and/or rib mesh been made aware of the risk of: - drill rigs being operated inadvertently by operators, or inadvertently operating of their own accord?		
		✓			✓	Training	Have persons involved with the installation of roof and/or rib mesh been made aware of the risk of:- placing hands in contact with roof or rib mesh while there is a risk that the mesh may become entangled by a rotating drill steel?		
		✓			✓	Training	Have persons involved with the installation of roof and/or rib mesh been made aware of the risk of:- placing hands on rotating and sliding parts of the drill rig?		
					✓	Training	Have persons involved with the installation of roof and/or rib mesh been made aware of the risk of:- escape of fluid?		
		✓			✓	Training	Does the training provided on the roof bolters include challenge testing / competency assessments?		
		✓			✓	Training	Are these competencies re-assessed at regular intervals (Section 5.1.3) (note the frequency of reassessment)?		