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International Journal of Industrial Ergonomics 37 (2007) 145–155

International Journal of INDUSTRIAL ERGONOMICS

www.elsevier.com/locate/ergon

Implementation of the Participative Ergonomics for Manual tasks (PErforM) programme at four Australian underground coal mines

Robin Burgess-Limerick[a,*], Leon Straker[b], Clare Pollock[c], Gary Dennis[a], Sue Leveritt[d], Suzanne Johnson[a]

[a]*School of Human Movement Studies, The University of Queensland, Australia*
[b]*School of Physiotherapy, Curtin University of Technology, Australia*
[c]*School of Psychology, Curtin University of Technology, Australia*
[d]*Minerals Industry Safety and Health Centre, The University of Queensland, Australia*

Available online 11 December 2006

Abstract

This case study describes the collective lessons learned through the implementation of the Participative Ergonomics for Manual tasks (PErforM) programme at four Australian underground coal mines. Between 13 and 25 days were spent at each site to introduce the programme, train staff in manual tasks risk management, conduct workshops addressing specific tasks, facilitate site-based committees in implementing the results of these workshops, and assist sites implement processes to facilitate ongoing miner participation in reducing injury risks associated with manual tasks. This paper describes the project, presents examples of the risk assessments undertaken and resulting control suggestions; and discusses the varying degrees of success encountered and lessons learned.

Relevance to industry

Coal mining continues to be a significant source of musculoskeletal stress and injuries. The primary aim of the programme described here was to reduce injury risks associated with manual tasks performed by miners. Examples of the risk assessments undertaken and resulting control suggestions are provided and lessons learned during the project are described.

Keywords: Participative ergonomics; Coal mining; Manual tasks

1. Introduction

Approximately 40% of compensation claims across all Australian industries are for musculoskeletal injuries associated with manual tasks (NOHSC, 1998). The prevalence may be even higher in Australian coal mining, where musculoskeletal injuries (sprains and strains of joints and adjacent muscles) represented 67% of compensation claims involving five or more lost days (1994–1999, National Workers' Compensation Database—http://nohsc.info.au.com/).

One approach to reducing the burden from musculoskeletal injuries is participative ergonomics. Participative ergonomics developed from Asian, European and North American management practices of quality circles, industrial democracy and corporate control (Noro, 1991; Jensen, 1997; Brown, 1993). Many variations in the models and techniques used in participative ergonomics have developed including the facilitation role of the ergonomist and the training provided to work teams (see Haines and Wilson, 1988 for a review). However, a common element is to ensure utilisation of the expert knowledge that workers have of their own tasks by involving the workers in improving their workplaces. Management commitment and provision of resources; workers and management understanding of relevant ergonomics concepts and techniques; and a process to efficiently develop and implement suggested controls appear to be important components of successful participative ergonomics interventions (cf., Haims and Carayon, 1998; Laing et al., 2005).

*Corresponding author. Tel.: +61 7 3365 4718; fax: +61 7 3365 6877.
E-mail address: robin@hms.uq.edu.au (R. Burgess-Limerick).

0169-8141/$ - see front matter
doi:10.1016/j.ergon.2006.10.008

Participative ergonomics is reported to have benefits including an improved flow of useful information within an organisation, an improvement in the meaningfulness of work, more rapid technological and organisational change, enhanced performance and reductions in work-related health problems (Brown, 1993; Haims and Carayon, 1998). A potential disadvantage of participative ergonomics is that the process may be a relatively inefficient way of arriving at control solutions because of the time required for workers involvement. It is also possible that solutions arrived at may be sub-optimal (Wilson, 1995).

Participative ergonomics has been used to create more human centred work (Imada, 2000), to improve work organisational climate (Maciel, 1998) and to try to prevent musculoskeletal disorders associated with manual tasks. Participative ergonomics interventions aimed at reducing musculoskeletal disorders have been trialled in electrical and metal products manufacturing (St-Vincent et al., 2001), car manufacturing (Halpern and Dawson, 1997), meat processing (Moore and Garg, 1997; NIOSH, 1994), print media (Rosecrance and Cook, 2000), construction (de Jong and Vink, 2000) and health care (Bohr et al., 1997; Evanoff et al., 1999; Straker, 1990) industries.

This paper reports a multiple-case study of the implementation of a Participative Ergonomics for Manual tasks (PErforM) programme at four Australian underground coal mines during 2003–2005 funded by the NSW Coal Services Health and Safety Trust. The primary aim of the programme was to reduce injury risks associated with manual tasks performed by miners. Examples of the risk assessments undertaken and resulting control suggestions are provided and lessons learned during the project are discussed.

2. The PErforM programme

In addition to principles of participative ergonomics, the PErforM programme also adopts a risk management cycle of hazard identification, risk assessment, risk control and evaluation; and a hierarchy of risk control strategies as an underlying principle. Elimination of manual tasks is always preferred, followed by design changes to remove or reduce hazards (engineering controls), with ‘administrative’ controls such as task rotation or skills training suggested only as supplementary measures, or as short-term controls while elimination or design controls are explored. In this way, the PErforM programme is conceptually similar to programs described by St. Vincent et al. (2001) and Wells et al. (2000).

This approach to manual tasks risk management requires work teams to be knowledgeable about the risk management framework, to have the skills and tools required to assess manual tasks risks, to understand the risk control hierarchy, and to have knowledge of general principles of control strategies for eliminating and controlling manual task risks. Training workers to acquire these skills and work within a risk management framework is consequently a key concern.

Team members identify hazards in their work and are facilitated through a risk assessment process which requires them to develop control suggestions. The work teams plan the implementation of key controls and are subsequently shown how to evaluate those controls. Management commitment and effective risk management systems are required for the approach to be effective, and access to external ergonomics expert assistance may be necessary for particularly difficult or complex problems.

A randomised controlled trial of PErforM was conducted and demonstrated positive outcomes for the workplaces involved (Burgess-Limerick, 2004; Straker et al., 2004). The workplaces involved in this trial were relatively small (30–100 staff) single-workplace employers in three diverse industries (nursing homes, food manufacturing, and construction related manufacturing and wholesaling). A significant reduction in manual task injury risk as assessed by government inspectors was reported for workplaces receiving the intervention.

Some work has previously been undertaken outlining the application of ergonomics in coal mines (Andrew and Simpson, 1993; McPhee, 1993), and mining more generally (Gallagher, 1998). There is also a considerable history of investigations of the role of autonomous work teams in coal mining (Trist et al., 1963). However, as Culvenor et al. (2000) noted in their review of occupational health and safety priorities for the Australian coal industry, there is a lack of research in the area of manual tasks injury prevention, both nationally and internationally.

In mining, as in industry more generally, we believe the focus of preventing manual tasks injuries must be on reducing overall manual tasks risk factors. What is needed, as Simpson (2000, p. 262) puts it, is “a detailed and systematic risk assessment system” and “a little more creativity and imagination when developing risk control measures”. The aim of this project was to provide the necessary risk assessment system, and harness the creativity and imagination of workers through the participative ergonomics process.

Underground coal mines represent very different workplaces to those in which the PErforM programme has previously been implemented. They typically have a much larger work force; are usually part of large, often multinational, companies; have sophisticated safety management systems; experience very different environmental risks and constraints; and experience greater regulatory constraints and inspectorial attention.

2.1. Site selection

Site participation was solicited through presentations made at two seminars held by the funding agency to inform the industry of current mining safety research. Expressions of interest in the programme were received from six sites, with four finally agreeing to participate. The four sites

Table 1
Site characteristics

Site	State	Owner	Age (years)	Seam Ht (m)	Longwall face (m)	Production (Mtpa[a])	Employees (no.)
A	Qld	Multinational	8	3.4	270	4.1	200
B	Qld	National	15	2.6	260	4.8	160
C	NSW	National	120	3.4	160	1.7	140
D	NSW	Multinational	13	2.8	198	3.6	140

[a]Millions tonnes per annum.

cannot be considered a random sample. While participation did not require funding from the companies, commitment to the project did require a significant commitment of resources in the form of miners' and safety staffs' time for training and workshop participation, and participation in related committee meetings. By volunteering to participate, the sites demonstrated a significant degree of management commitment and are likely better than the industry average in that respect. In other ways the sites are typical of underground coal mines in Australia and are drawn equally from the two major coal producing states (Queensland and New South Wales). At the time of their participation in the project, the mines all had different parent companies, two being large multi-nationals. All were long-wall mines with relatively high seam heights (by international standards) mining between 1.7 and 4.8 million tones/annum (the Australian average being 3 million tonnes in 2004/05). The mines all utilise integrated bolter miners, a standard Australian practice, but one which varies internationally. Table 1 provides relevant characteristics of the sites.

3. Implementation of PErforM at four underground coal mines

The PErforM programme is designed to be flexible to accommodate individual site requirements, and resources committed by the sites. The number of visits, number of miners involved, and activities undertaken varied within the project framework to accommodate these differences. The programme components may broadly be defined as introductory and preparatory visits; training and workshop visits; and facilitation visits. The structure is broadly similar to that employed by St. Vincent et al. (2001). Table 2 provides a break down of the arrangement of these visits across the sites.

Sites agreeing to participate were visited twice to introduce the programme to management and miners, to determine appropriate high risk tasks for consideration in subsequent workshop sessions (and obtain video footage of the tasks where possible), and to make logistical preparations for the subsequent training and workshop sessions.

The majority of the visits to each site comprised a mixture of training sessions and workshops. During 2 h training sessions, intact work teams were provided with information about manual task injury risk management.

Table 2
Visits to each site by activity undertaken

Site	Initial visits	Training/workshops (number of miners involved)	Facilitation/ follow up	Total days
A	2	18 (116)	5	25
B	2	9 (30)	2	13
C	2	7 (46)	3	13
D	2	18 (132)	4	24

The topics covered included mechanisms of injury associated with manual tasks; direct risk factors (exertion, awkward posture, vibration, repetition and duration); hazard identification and the use of a manual task risk assessment tool to assess the severity of the hazards; the importance of the hierarchy of controls; and general strategies for eliminating and controlling manual tasks injury risks.

The assessment of manual tasks risks in PErforM is conducted using a simplified version of Manual Tasks Risk Assessment tool (ManTRA) which was devised for use by Workplace Health and Safety Queensland inspectors during workplace audits (Burgess-Limerick, 2004; Straker et al., 2004). The simplified version requires assessors to nominate the body region or regions at risk and to provide a rating on a five-point scale for each of the five risk factors (exertion, awkward posture, vibration, repetition and duration) for specific body regions. The scores are used to provide a "risk profile" for that body part, and assist with identifying aspects of the tasks to which control measures should be targeted. Training in the use of this tool is assisted through the use of industry specific, and workplace specific, video footage. The risk assessment training focussed on providing an understanding of the direct risk factors highlighted in the PErforM risk assessment tool, using industry specific footage to develop a shared understanding of use of the tool provide to assess exposure to each risk factor. Training in manual tasks risk control highlighted the importance of the hierarchy of control measures, and of the importance of ensuring all avenues for elimination, or control by design, are explored in concert with administrative controls.

Following the training sessions (sometimes the same day, or at a later visit) the teams participated in a 3 h workshop in which they were facilitated to address a high risk task performed in their workplace using the tools and methods described in the previous training session. Examples of the results of these workshops are provided in Appendix A. The examples provide a description of the relevant characteristics of each task, a completed risk assessment form (using the PErforM matrix), and a collation of design and administrative control options suggested by miners during the workshops.

Each site formed a committee to coordinate the evaluation and implementation of the control suggestions, typically comprised of safety staff, site engineer, miner representatives and a management representative. Subsequent visits were undertaken at each site at approximately monthly intervals to assist this committee, as noted in Table 2; however, the aim was for the committee to take ownership of the participative ergonomics process and for it to become self-sustaining.

Site A initially made good progress towards a self-sustaining process; however, recent staff turnover has the potential to interfere with the effective functioning of the site committee. The process towards becoming self-sustaining was curtailed at site B as the result of a change in mine ownership, with a consequential change in mine management, during the training phase. Progress at Site C was also initially promising; however, again it appears that staff turnover may have robbed the site of the project champion. Site D has exhibited the greatest progress towards becoming self-sufficient, having recently adopted the PErforM process within their "site standards" which guide the management of safety risks. Embedding the process within the site standards makes it more likely to withstand a change in site personnel.

4. What we have learned

Management at the coal mines were acutely aware of the substantial compensation costs associated with the manual tasks related injuries sustained by their staff. They were also extremely concerned by the increasingly older age profile of their staff. The general industry trend is toward leaner workplaces producing more coal with fewer staff. The need to reduce exposure to cumulative loading was appreciated by management. Despite considerable advances in mining technology, underground coal mining is still characterised by relatively high exposure to hazardous manual tasks. While "production" loomed large in the consciousness of management, there was also a genuine commitment to safety. In short, there was evidence across the participating workplaces of *management commitment* to reducing manual tasks risks. This is perhaps not surprising given that the site management had agreed to participate, and may not be representative of the industry as a whole.

The risk assessments and control suggestions documented in this paper demonstrate that after a relatively short training period, and given appropriate tools, coal miners were able to undertake manual task risk assessment and generate potential control options. The use of industry and *workplace-specific video footage* during the training has again appeared to be an effective way of both conveying the skills and knowledge required, and also in maintaining motivation and attention of the trainees (cf., St. Vincent et al., 2001).

The mines involved had *highly developed safety management systems*, and this combined with the low industry staff turnover created opportunity for skills in manual task risk assessment and control to be utilised and for design changes to be implemented. Conversely, the *size* of the organisations, and the *complexity* of the workplaces, *created challenges* for ensuring that the control suggestions resulting from the participative ergonomics process were evaluated, trialled, and implemented.

The additional hazards of working in an *underground environment* such as the overriding concern regarding the control of ignition sources means that implementing controls for underground coal mining can be particularly slow. Materials that may be available for use in an above ground operation (such as aluminium) cannot easily be introduced in the underground coal environment. Certifying new designs takes *time*. This can be frustrating for the workers concerned, and lead to a feeling of dissatisfaction with the process. Bohr et al. (1997) noted similar issues occurring in the context of a large hospital, although the time delays arose from different causes. The initial implementation of quick controls, even if they are not the highest risk tasks, may be beneficial to maintain motivation.

A person onsite who drives the process appeared to be essential—this person needed to have easy access to, and support from, management to proceed with projects. Sites where such a person did not emerge, or did not stay at the site, struggled to realise implementation of the suggested controls. The importance of a site champion was similarly commented on by Wilson (1995), and by Laing et al. (2005), although the latter suggested that this person may require substantial ergonomics expertise, which we did not find to be the case.

While *team supervisors* were encouraged to participate, they sometimes chose not to, reasoning that their presence may negatively influence the willingness of crew members to contribute to the process. When this happened a degree of experience was missing from the teams performing the risk assessment and control exercise. The supervisor was also an important link in the management chain to the level where decisions about time and costs would be made. Thus, a high level of 'buy in' from the supervisor was a factor that contributed to the successful and timely implementation of control measures.

It appeared to be important, particularly given the delays that typically occur, that *communication* with the teams involved in a project was maintained. Even if there was no progress to report it was critical that workers understood that the process was still underway. This was well handled at site A where an ergonomic task group remained active following the implementation phase of the project. The crews have been very receptive to the discussion and meeting minutes that came back to them. Tasks on the agenda of the committee included: redesign of a Load–Haul–Dump vehicle to reduce the whole body jarring, dismantling of belt structure, and retrofitting a jib to be used to deliver long-wall legs to the tailgate end of the long-wall. Management at the site approved paid overtime for those attending these meetings on their days off.

Part of the attractiveness of the participative ergonomic process appeared to be the *sense of ownership* that developed over a control idea that is implemented. In discussion with management within some of the mine sites, most were able to identify one or two controls that have been implemented over the years that just did not "catch", at some expense. It is likely that a lack of participation is to blame is at least some cases, given that traditional change implementation strategies have been "top-down".

In the process of taking an idea and creating a design, *engineers* may sometimes fail to check with the end "user" throughout the cycle and consequently fail to produce a product which satisfies the real needs. An example of this occurred at one site where a long-wall crew developed an idea for a trolley to transport equipment along the long-wall face. The engineer designed a sufficiently large trolley to allow it also be used for less regularly moved, and even heavier, pieces of gear as well as the load intended by the miners. The miners declared the weight of the trolley excessive and have continued to carry all items in pairs or use the slow chain block procedure of feeding the equipment along the "face". This problem may have been avoided if the participative approach had been fully embraced and feedback sought throughout the development of the control.

There were greater obstacles to communicate directly with employees on *shiftwork*. Seeking feedback for a change or modification to plant and equipment from all users is not easily done and was not often done very well. There was often a lack of communication between different crews (i.e. day, afternoon and 'dog-watch' shifts). This manifested some problems in terms of coming up with a consensus for control measures. (e.g. one crew wanted the design of the rails to be changed on the continuous miner while other crews had previously designed the current design to work for them). There was also a general perception that management followed what a particular crew (usually day shift) said more than other shifts. In addition, this lack of communication often surfaced in the workshop sessions where one crew had an effective technique for performing a task whereas other crews were struggling with the same task.

Another *communication failure* was illustrated when at one workshop session the miners' major control measure was to design a rig to help install over-head pipes. At a subsequent workshop, another crew pointed out that such equipment had already been designed and built, and was sitting unused in a section of the mine as no one liked it. When probed as to what was wrong with it, nobody knew.

If an idea has been trialled and "failed" a few years ago, it may be worth revisiting the concepts and considering alternatives in light of subsequent technical developments. This is difficult to do without available documentation. *Documenting both successes and failures* is an important step, but one which was not systematically achieved at most sites, nor indeed is it an explicit part of all participative ergonomics approaches (although see Wells et al., 2000 for an example of its inclusion).

Site staff turnover was a factor that effected the progression of control ideas at some sites. People responsible for overseeing changes and designs leave and the ideas often depart with them. This occurred at one site during the project where a member of staff left and with him went all knowledge of a trial he had just conducted for a short-term control for belt lifting.

The PErforM tool was easily understood and the risk management approach and control hierarchy was a familiar strategy to all in the mining industry. An impressive product of the tool was the *speed* with which both the nature of the risk and the suggested control ideas were generated. This experience argues against the charge that a participative process is less efficient than a top-down model. The information obtained typically required considerable refinement following the "brainstorming" stage; however, the benefits of having a number of experienced operators involved in the process cannot be over-stated.

It is at the "*refinement*" stage that the process had the greatest potential to break down. The expertise drawn upon to identify the nature of the risk and to suggest control ideas may not be the same expertise that is needed to design and implement the controls. Input from other areas may be required for a variety of reasons, including:

- ensuring that materials introduced into the underground environment are intrinsically safe,
- ensuring that the use of new controls will not create a flow-on effect on any other part of the operation,
- ensuring that costs are realistic,
- ensuring that controls comply with regulatory requirement, site and company guidelines.

5. Conclusion

While there is no doubt that the participative ergonomics process described here has the capability of producing effective control solutions, achieving this potential and translating the results into reduced risk exposure required the genuine commitment of management to implement control measures identified during the project. Equally important was that this commitment was perceived to exist by the workers. Consequently, the role of the facilitator of participative ergonomics often needed to extend beyond purely providing manual tasks risk control skills, but also to facilitating communication between management and workers. Other threats to the successful implementation of control suggestions included turnover of key staff and failure to ensure sufficient participation in the implementation stages.

Acknowledgements

This research was funded by the Coal Services Health and Safety Trust (NSW). Revisions to the manuscript were completed while the first author was a National Academy of Sciences Senior Research Associate at the National Institute of Occupational Safety and Health Pittsburgh Research Laboratory (USA).

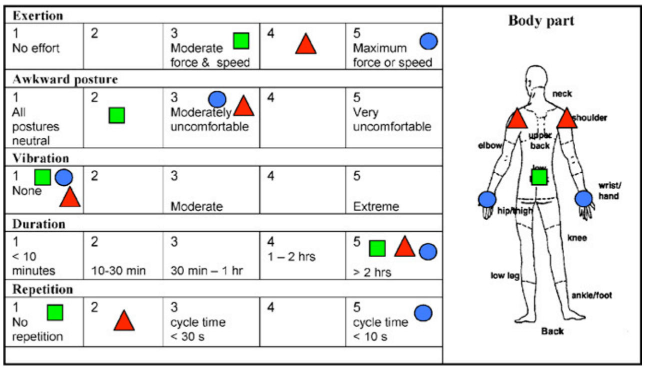
Appendix A. Four tasks addressed during participative ergonomics workshops

Example 1. Gas drainage

Task description

Name of task: Gas drainage
Why was this task selected: The sole task of the gas drainage crew is to extract dangerous gases from the development panel in preparation for coal extraction. As a result, miners in this crew perform a single task for the duration of every shift. The repetitive and continuous nature of this task has led to a number of cumulative injuries, particularly to the shoulders and wrist
Location where task occurs: Development panel
Who performs the task: A two-man teamwork together each shift performing the gas drainage task using a purpose build gas drainage drill rig. One member of the team generally operates the rig while the other team member performs all manual tasks for the duration of a shift. Generally they rotate jobs for the next shift
General description: A 2.4-m-long steel tube (12 kg) is lifted from a near by storage pod and placed onto the feed bed of the drill rig. Once the previous length has been drilled, the water swivel at the end of the tube is unscrewed and the next tube is lifted and screwed into the previous tube. The water swivel is then carried to the end of the new tube and screwed into the back of that section. Often a shifting spanner is needed to tighten or loosen the threads. The rest time between each tube (while drilling takes place) is typically 2–3 min, and anywhere from 200–600 tubes maybe installed and/or removed in a shift
Postures: Awkward postures of the back, shoulders and forearms occur; when bent over the feed bed, lifting the tube from a high position of the storage pod and during the screwing task
Forceful/muscular exertions: Large muscular exertions are required by the muscles of the back, shoulder and forearm when lifting and positioning the tubes, and in the wrist extensors and flexors when screwing each new section to the previous tube
Repetition and duration: The team member performing the manual task during the shift handles and screws anywhere from 200–600 tubes in a shift, and does this task for the duration of the 8-h shift
Tools or equipment used: Drill rig, 2 m tubes (12 kg), water swivel (3.6 kg) and shifting spanner
Work/task organisation and environment: Conditions that make this task awkward are the uneven and muddy floor conditions and the repetitive nature of the task with no job rotation during each shift

Risk assessment



Comments

This is the only task performed by the gas drainage crews, and if no job rotation occurs during the shift, then the team member performing the manual tasks associated with this task will do so for the duration of the shift. In particular, the shoulders and the wrists have been identified as the areas of greatest risk of musculoskeletal injury. Based upon an average of 200 tubes being installed or removed each shift and if six rapid wrist extensions and/or contracts are required for each thread then the miner will perform 3600 rapid forceful wrist rotations per shift.

Risk controls

Design control options:

- Move the feed bed on the older drill rig to edge of the rig so that it is closer to the miner and reduces the moment arm relative to the lumbar spine and shoulders when handling the tubes
- Look into a new clipping mechanism between the tubes so that don't have to be screwed into one another
- Knurl the water swivel so that it is easier to grip and thus reduces the grip pressure required by the miners. Additionally, change the flat section at the rear of the water swivel so that it is a hexagonal rather than two flat sections and provide a fixed spanner rather a shifter to fit the hexagonal nut precisely
- Affix a rotational lever system on the water swivel to increase the moment arm while tightening or loosening the water swivel

- Move or remove the cable reel from the older drill rig to improve the access to the back of the miner
- Examine if the pivot point on the back of the miner can be moved closer to the front of the drill rig to reduce the torque required to align it with the previous tube
- Ensure that there is a regular maintenance or replacement of the tubes so that the threads are easy to screw while still remaining water tight. Leaking tubes resulted in muddy conditions around the rig, which increased the slip and trip hazard

Administrative control options:

- Rotate the two man crew within the shift not just between shifts
- Instruct the miners to share the load between the flexors and extensors of the wrist during screwing tasks by alternating between overhand and an underhand position on the tubes
- Develop a SOP that involves fitting the next tube while standing alongside the joint rather than at the far end of the tube and pushing against the pivot point to align it

Example 2: Roof bolting

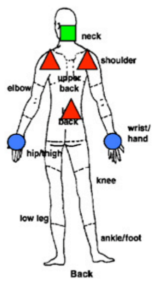
Task description

Name of task: Roof bolting on an integrated continuous miner bolter with 7-ft roof bolts
Why was this task selected: Roof bolting is one of the primary tasks of the development crew, and makes up 60–70% of the total work time for the two-man crew on the miner. It is a repetitive task (approx 50 bolts per man per shift) that involves awkward postures and can be physically demanding, particularly on the back, shoulders and forearms
Location where task occurs: Development panel
Who performs the task: A two-man face crew performs the task, one is also the miner driver. These two miners perform the task for the duration of the 8 h shift except during crib, when they are relieved for up to an hour
General description: Two bolts are usually manually carried from the pod at the rear of the miner and placed pointing up in front of the drill rig. A 7-ft drill steel is placed into the drill rig and used to drill into the roof. Once the hole is drilled the steel is removed and a dolly is inserted into the bottom of the rig. A 7-ft bolt (7 kg) is then placed into the dolly along with a face plate and the jaws on the top of the rig are closed around the bolt. A chemical agent (in a tube) is fed up into the hold and is pushed up via the bolt. The roof mesh is then set in place before the bolt is screwed and set into place
Postures: Awkward postures of the back, shoulders and forearms occur; when bent over due to low seams, reaching around the drill rig to insert/remove rods or drill steels (particularly for the inside bolt) and when reaching overhead to insert and fed the chemical into the hole
Forceful/muscular exertions: Large muscular exertions are required by the muscles of the back, shoulder and forearm when handling the bolt, and are also often required when the mesh catches on protruding objects. Additional effort is required when moving and storing the box of chemicals and the plate sets on the miner
Repetition and duration: Each crew member bolts 30–50 bolts over an 8 h shift
Tools or equipment used: Continuous miner, 7-ft bolts (7 kg), 7-ft drill steels, plates, chemicals and roof mesh (5 × 1.2 m)
Work/task organisation and environment: Conditions that make this task awkward include:, uneven and muddy floor conditions, low roof obstacles (e.g. bolt tails), protruding objects on the miner which catch the roof mesh and the confined space of the miner's platform due to the wide throat of the miner

Risk assessment

Exertion				
1 No effort	2	3 Moderate force & speed ■	4 ▲	5 Maximum force or speed ●
Awkward posture				
1 All postures neutral	2	3 Moderately uncomfortable	4	5 Very uncomfortable ■ ▲ ●
Vibration				
1 None ■	2 ● ▲	3 Moderate	4	5 Extreme
Duration				
1 < 10 minutes	2 10-30 min	3 30 min – 1 hr	4 1 – 2 hrs	5 > 2 hrs ▲ ■ ●
Repetition				
1 No repetition	2	3 cycle time < 30 s	4	5 cycle time < 10 s ■ ▲ ●

Body part



Comments

This is the primary task performed by the development crews, taking up to 60–70% of the shift for those miners on the continuous miner. Bolting involves a lot of strain on the back, shoulders and forearms when lifting the rods and drill steals into the drill rig. In addition, bolting involves a lot of repetition (50 rods per shift) and many awkward postures. As a result, all three development crews identified roof bolting as the number one task in need of an appropriate intervention to reduce musculoskeletal injury risks.

Risk controls

Design control options:

- Make the platform height adjustable so that tall miners can stand upright while drilling and do not have the risk of hitting their heads on the exposed rod tails in the roof. In addition the tails of the exposed rods can be trimmed via a hydraulic cutter
- Install/extend the platform near the drill rig so that the miners can get closer to the rig, which will reduce the

need to extend the arm while inserting the rods, steals and dollies. This extended platform section should be designed so that it is attached to the bottom of the rig and so it moves as the rig is moved in and out for the inside and outside bolts
- Lower the height of the drill motor so that the rods are easier to place in the dolly
- Redesign the dolly (i.e. chuck) so that it fits both the rods and drill steels, thus the dolly doesn't have to be continually changed
- Purchase a new miner with a smaller throat, which can better accommodate the drill rigs and as a result reduce the awkward postures involved with the current position of the drill rigs
- Look into new automated bolting technology, which is currently being trialled elsewhere. These bolts automatically drill, and are fixed in with cement which is contained within the bolt
- Look into the placement of mesh sheets (15–30) on top of the miner so that the miners do not have to walk them over head from their storage place along the ribs
- Look into smaller diameter vent tubes which allow for more room on that side of the miner
- Look into extending the mesh sliders and/or cross beams on the sliders to aid in the movement of the mesh across the miner
- Reduce the materials that the mesh can get caught on e.g. headlights, loose materials in the storage bins, etc.
- Build specific stage bins for the chemicals and plates that are also positioned closer to the drill rig if possible
- Purchase/order the chemicals with a lower number of tubes (10–15) per box

Administrative control options:

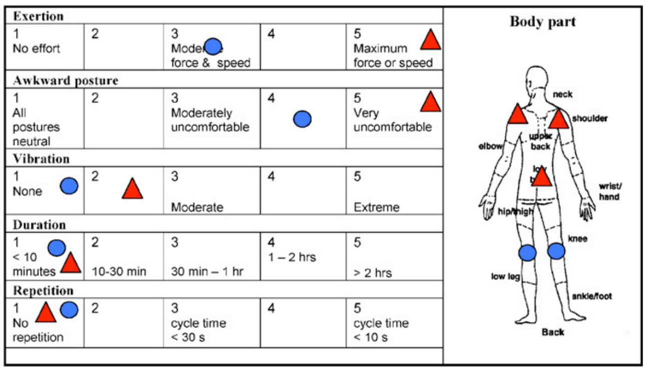
- Extra man on the continuous miner to help with job rotation and adding in moving mesh
- Train more miner operators to allow for job rotation
- Ensure the replacement of crew members who are sick on a shift to ensure that it doesn't place extra stress on the rest of the crew, and allows for job rotation
- Train all operators about the correct storage of the equipment on the miner (i.e. improved housekeeping) so that the mesh is less likely to get caught while being moved across the miner

Example 3: Dismantling and removing the monorail

Task description

Name of task: Dismantling and removing the monorail
Why was this task selected: Two sections of the monorail are removed after each dual pass of the shearer on the face (approx. three per man per shift). Not only is it a routinely performed task but removing each monorail rail section (34 kg) involves both large forces and awkward postures. Furthermore, this task has been previously identified as incurring significant musculoskeletal risks but currently remains an unresolved issue
Location where task occurs: Long-wall belt road (BSL)
Who performs the task: This task is commonly performed by the main gate operator and/or other members of the long-wall crew. Although this task has been mandated by management as a two-man job, it is occasionally performed by a single crew member
General description: Once the temporary chain is attached under the monorail at the in-bye (towards the face) end of the rail, the locking pin between the rails is knocked out using a claw hammer. Both rails are then lifted (often arms over head) and the suspension chains are removed. Next, the temporary chain is removed and the rails are levered apart and the in-bye rail is dropped/lowered manually by the miner. Finally, the in-bye bracket and nut is removed before carrying the rail to the out-bye cut-through (perpendicular to the main shafts in a direction away from the face) and placed into the storage bucket. *Note*: slight variations in this procedure occur between the miners and the different crews
Postures: Awkward postures of the back and shoulders occur; when leaning backwards over the rail to remove the locking pin and chains and when lifting and lowering the rails. In particular hyperextension and twisting of the spine and overhead reaching postures are currently required to perform the task as the platform is not directly under the monorail
Forceful/muscular exertions: Large muscular exertions are required to hammer out the locking pin and to lift, lower and carry the heavy (34 kg) rail sections
Repetition and duration: The removal of each section takes approximately 10 min and each miner performing this task would typically remove 3–4 rail sections per shift
Tools or equipment used: Claw hammer, pin punch, temporary chain and rail sections (34 kg and 2 m long)
Work/task organisation and environment: Conditions that make this task awkward include: variations in the height and alignment of the platform with the monorail and the poor floor conditions while carrying the rail section up to 100 m along the belt road back to the storage bucket

Risk assessment



Comments

Dismantling the monorail is a task that is routinely performed by members of the long-wall crew as sections of the long-wall are mined by the shearer. The primary concerns raised by each of the three crews who analysed this task in the workshop were; the large forces required to perform the task due to the heavy nature of the rails, the awkward postures required as the platform is almost always not positioned under the monorail, and finally the unresolved issue of carrying the rails up to 100 m to the out-bye cut-through instead of having a bucket which is more conveniently located.

Risk controls

Design control options:

- Make the platform hydraulically adjustable both in and out and up and down. Being able to vary the position of the platform under the monorail will significantly reduce the awkward postures involved in the task (e.g. spinal twisting and hyperextension), while varying the vertical position of the platform will cater for the varying standing heights of the miners and reduce stress on the shoulder by minimising the overhead work performed by the arms. In addition, the hydraulic platform could also be used to raise the rails up while removing the chains via a lifting ram with a roller on top that couples to the underside of the rail and is attached to the edge of the platform. However, the new risks associated with this addition to the platform would have to be assessed
- The platform at the in-bye end could be extended to enable the rails to be removed after the 2nd main gate push. This would reduce the time constraints placed on the miners to remove the first rail between the 1st and 2nd pushes, as currently the platform would not be in place to remove the first rail after the 2nd push
- A long crowbar with a hook could be used to raise the monorail to remove the chains and lower the rail once the chains are removed, thus reducing the force required to lift and lower the rails. This technique has been dubbed the "Naz Lift" after the miner who came up with the idea
- Look into purchasing a new locking pin design (e.g. a split pin) that doesn't require a forceful blow by a hammer to remove the pin
- If the current pins are retained, a hammer with a longer handle would reduce the force required to remove the pin and also reduce the incidences of the hands being pinched against the rails
- Look into the possibility of reducing the weight of the rails by drilling holes in them or alternately purchasing lighter weight rails
- Look into the cost associated with leaving the monorail (to be buried as the long-wall retreats) versus the costs (both time and injury costs) associated with its removal
- Build a monorail cassette storage bin that travels along the out-bye end of the monorail so that each rail section doesn't have to be carried back to the cut-through. *Note*: this cassette will have to carry at least 50 rails, and a full design was developed in the workshop session

Administrative control options:

- Training for those involved in moving the storage pods for the rails should conducted to reduce unnecessary distance that the rails have to be carried. The pods should only be moved just before the construction
- The dismantling of the monorail task should always be conducted by at least two crew members, and appropriate staffing and work practices should allow for this

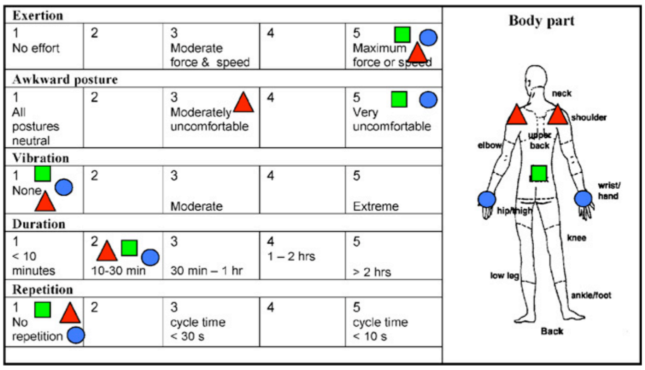
Example 4: Pump change out

Task description

Name of task: Pump change out
Why was this task selected: This task was selected because the design and location of the pump requires particularly heavy and awkward lifting. In addition, this task is often performed by one person and in muddy conditions
Location where task occurs: In underground muddy areas that require the removal of excessive water
Who performs the task: Generally the out bye deputy performs this task on their own
General description: Whenever a pump in no longer functioning properly it is changed. First a new pump (often 50 kg) is loaded into a mine vehicle on the surface. It is then driven to the site of the old pump and unloaded from the back of the vehicle. The old pump is disconnected and the new one fitted. The old pump is then loaded onto the vehicle and unloaded on the surface
Postures: Bending and twisting of the trunk is required to lift the pump in and out of the back of the SMV and the arms in particular are fully extended due to the large size of the pump
Forceful/muscular exertions: Maximal muscular exertions are required by the muscles of the back, shoulder and forearm when lifting and carrying the pump (50 kg)
Repetition and duration: This task is performed on average once per week and the manual handling component of the pump change out lasts about 20 min
Tools or equipment used: Various pumps depending on the volume of water that needs to be moved (up to 50 kg) and the vehicle
Work/task organisation and environment: Conditions that make this task awkward are the uneven and

muddy floor conditions in the wet areas of the mine

Risk assessment



Comments

This task is strenuous because the pump is particularly heavy and is difficult to move through often muddy conditions. A circular frame has been fitted to the outside of the pump so that it can be more easily rolled to and from the vehicle. However, the circular nature of this frame also causes it to slip/rotate on the vehicle step which makes it more difficult to lift into the vehicle. If the pumps were lighter the risks associated with this task would be significantly reduced. Alternatively, if the pumps were more durable or if they could be serviced at their underground location the risks may be almost eliminated as the task would be rarely performed.

Risk controls

Design control options:

- Install an in-line air filter and in-line oil lubricator so that the pump breaks down less often and the task rarely needs to be performed
- Train certain miners in the maintenance of the pumps (which may be quite simple) so that they can be serviced on site rather that transporting them to an outside service department. This not only would reduce risk it may very well save time and money
- Use lighter weight pumps, either two lighter pumps in parallel or purchase newer pumps which although lighter still can move the same volume of water
- Install a small Hyab crane on the back of the vehicle to aid in lifting it into the vehicle
- Install a boat winch on the back of the vehicle to aid in lifting it into the vehicle
- Use a rope on the frame of the pump to stop it slipping when manually lifting it into the back of the SMV
- Store pumps on the surface at waist height rather than in a container at floor level

Administrative control options:

- Mandate the task as a two man job
- Use a Load–Haul–Dump vehicle rather than a man transport vehicle to move the pump
- Only move the old pump out when there are two men available to perform the task

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