

## INITIATING AN ERGONOMICS PROCESS AT A SURFACE COAL MINE

Richard L. Unger, Safety Engineer  
Fred C. Turin, CPE, Industrial Engineer  
William J. Wiehagen, Industrial Engineer  
Lisa J. Steiner, CPE, Safety Engineer  
Kim M. Cornelius, CPE, Industrial Engineer

National Institute for Occupational Safety and Health  
Pittsburgh Research Laboratory

Janet Torma-Krajewski, PhD., CIH, CPE, Industrial Hygienist

U. S. Department of Energy

### BACKGROUND

Musculoskeletal injuries have been identified as a significant and costly problem for the mining industry. The National Institute for Occupational Safety and Health (NIOSH) conducted the National Occupational Health Survey of Mining (NOHSM) to characterize health related agents found at U.S. mines (NIOSH 1996). An important part of this survey was to identify potential exposures to musculoskeletal overload conditions. A total of 491 mines (60 coal mines and 431 metal or nonmetal mines) were surveyed. The percentage of miners potentially exposed to each of the 12 musculoskeletal overload conditions defined by NOHSM was calculated for coal mining and then for metal and nonmetal mining (Zhuang and Groce, 1995). The average percentage, over all twelve conditions, for coal mining (26.2%) was significantly greater than that in metal and nonmetal mining (17.2%). The three most common musculoskeletal overload conditions were (1) bending forward, bending to the side, hyper extending, or twisting the neck or back; (2) unsupported, abducted elbows, forearms resting

on sharp edges, tossing motions at extremes of range of motion, or working with hands above shoulders; (3) lifting greater than 50 pounds, unaided. At least 35% of mine workers (over 40% of coal mine workers) were potentially exposed to each of these three conditions. An analysis of NOHSM results for 24 commodities associated with metal and nonmetal mining concluded that the potential exposure to ergonomic hazards for those miners was high compared to non-mining occupations (Winn et al, 1996). Exposure of mine workers to musculoskeletal overload conditions clearly plays an important role in the development of musculoskeletal injuries at coal, metal, and nonmetal mines.

In 1998, the Mine Safety and Health Administration (MSHA) submitted a formal request to develop a cooperative project with NIOSH to investigate musculoskeletal disorders in the mining industry. MSHA representatives believed that the available injury data was not accurately representing the extent of musculoskeletal disorders in the mining workforce. NIOSH researchers took this as an

opportunity to consider a comprehensive systems approach for examining ergonomics issues in mining. A research plan with three primary objectives was developed: assess musculoskeletal disorder risk factor exposures in mining environments; identify means to reduce hazard exposures through engineering, administrative, and work practice controls; and evaluate the effectiveness of ergonomics interventions.

To accomplish the second and third objectives, the NIOSH team decided that a formal ergonomics process needed to be installed at a cooperating mine site to identify and test the effectiveness of possible interventions. This paper discusses the steps taken to implement such a process at the Bridger Coal Company in Rock Springs, Wyoming.

## ERGONOMICS PROGRAMS

There is evidence that ergonomics interventions can be effective in lowering musculoskeletal discomfort and injuries for workers in a variety of industry settings. A study of four private sector ergonomics programs (GAO/HEHS, 1997), found that the number of reported injuries and illnesses per 100 full time workers in 1996 were from 2.4 to 6.1 less than in 1993, the year prior to full implementation of the programs. Ergonomic improvements may also result in increased productivity and higher product quality (Cohen et al, 1997).

Ergonomics programs provide a way for workers and employers to identify jobs that are physically demanding or causing problems, develop ideas to reduce the risk of the job, and track interventions to ensure that they are effective. The structure and implementation of an ergonomics program varies based on the makeup and goals of an organization. In general, NIOSH recommends a seven-step approach for developing an effective ergonomics program to address musculoskeletal injury concerns (Cohen et al, 1997):

1. Look for signs of potential musculoskeletal problems in the workplace, such as frequent worker reports of aches and pains or job tasks that require repetitive, forceful exertions.
2. Obtain management commitment in addressing possible problems and encourage worker involvement in problem-solving activities.
3. Provide training to expand the ability of management and workers to evaluate potential musculoskeletal problems. In particular, enhance their ability to recognize musculoskeletal disorder risk factors.

Risk factors are characteristics of the work setting that could contribute to the occurrence of an injury or increase the chance of a musculoskeletal disorder. The potential for a risk factor to contribute to an injury is usually affected by the duration of the worker's exposure. Common musculoskeletal disorder risk factors include:

- Poor posture
- Forceful gripping
- Heavy or frequent lifting
- Highly repetitive work
- Hand/arm vibration
- Contact or impact stress
- Bouncing or jarring

4. Gather data to identify jobs or conditions that are causing problems, using sources such as injury reports, medical records, and job analyses.
5. Identify new approaches for performing tasks that pose a risk of musculoskeletal injury and evaluate these approaches once they have been instituted to see if they have reduced or eliminated the problem.
6. Establish health care management to emphasize the importance of early detection and treatment of musculoskeletal disorders.
7. When new work processes are developed, take steps to minimize musculoskeletal risk factors.

This approach is consistent with the guidelines for meatpacking plants published by the Occupational Safety and Health Administration (OSHA, 1993). These guidelines have been used by general industry as the basis for many ergonomics programs.

Whatever forms an ergonomics program may take; there are several characteristics common to all programs that help to indicate their potential for success (GAO/HEHS, 1997):

- Strong management commitment to the goals and budgetary needs of the program
- The availability of training in team building and ergonomics
- Formation of diverse teams that are of a manageable size
- Encouraging worker input to help define the overall program and team objectives
- Frequent communication within the organization on the program's objectives, progress, and accomplishments

## **BUILDING AN ERGONOMICS PROGRAM**

To evaluate the effectiveness of ergonomic interventions within a mining organization, NIOSH needed to find a long-term partner to accept assistance with installing an ergonomics process and monitoring the effectiveness of the introduced interventions.

### **Finding a Cooperator and Obtaining Management Commitment**

With the assistance of a member of the National Safety Council Mining Division, NIOSH contacted several mines and asked them to participate. The safety director at Bridger Coal, situated outside Rock Springs, Wyoming, was familiar with the problems associated with cumulative trauma and musculoskeletal injuries and felt that an ergonomics program could have a positive impact. He arranged for NIOSH to make a presentation to all the mine's management on basic ergonomics principles, the

ergonomics approaches used by other companies, and risk factor identification.

The next step was to ensure commitment at the corporate level. The Bridger Coal safety manager arranged a meeting of safety personnel from within PacifiCorp's Generation Business Unit. NIOSH again presented the ergonomics approaches used successfully at other large corporations, as well as the expected benefits for Bridger Coal. The hope was that Bridger Coal would be the model for PacifiCorp's Generation Business Unit (and possibly for other mines across the nation). The outcome of this meeting was corporate approval to install an ergonomics process at Bridger Coal.

### **Forming and Training an Ergonomics Committee**

It is critical that the design of an ergonomics process allows both management *and* employees to participate. After reviewing approaches taken by other businesses, the mine management decided that forming an ergonomics committee would be the best way to establish the program at Bridger Coal. A new committee, separate from the mine's existing safety committee, would allow the company to more easily commit resources to changing its work environment and work philosophy.

The committee included representatives from labor and management, as well as the company's medical department. Committee members were asked to make sure they would have the time to devote to their new responsibilities. The mission they were given was simple and direct:

*Identify, evaluate and correct working conditions that need ergonomic improvement.*

With the committee formed, the members received a series of formal training sessions from NIOSH covering the following topics:

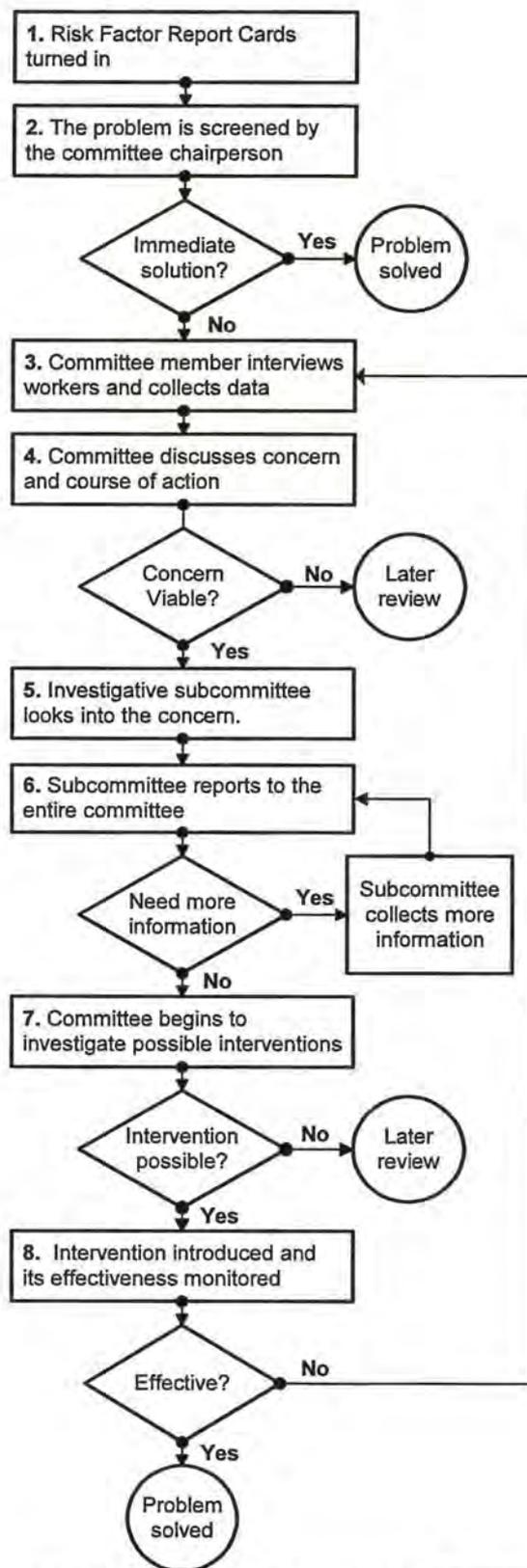
- An explanation of ergonomic programs, including why they are important to workplace safety
- Background information on successful programs at other companies (Ford, General Electric and American Electric Power)
- Basic principles of ergonomics
- Identification of ergonomic risk factors (poor postures, repetition, force, etc.)
- Selection of criteria for prioritizing work site tasks to evaluate
- Establishment of criteria for selecting interventions (timeliness, ease of implementation, cost/benefit ratio, etc.)

### Putting Together a Day-to-Day Process

The ergonomics committee developed a day-to-day process it would use to reduce employee exposure to ergonomic risk factors. Detailed below and diagramed in Figure 1 is the general process that the committee has implemented and is using to address issues that are not part of the NIOSH evaluation project:

1. An employee reports a concern to the committee. One way he or she can do this is by using a 4"×6" Risk Factor Report Card, readily available to everyone (Figure 2).

*(continued on pg. 44)*



**Figure 1.** Bridger Coal Ergonomic Process Flowchart.

1. Comments/suggestions:	<b>Risk Factor Report Card</b>
<p><b>2. Check all risk factors that apply:</b></p> <p>9 Poor Posture            9 Forceful Gripping</p> <p>9 Repetitive Work        9 Heavy Lifting/Carrying</p> <p>9 Vibrating Tools         9 Bouncing/Jarring</p> <p>Other risk factors: _____</p>	<p><b>3. Mark areas affected with an X</b></p> <div style="text-align: center;">  </div>
4. Name: _____	
5. Work area: _____	

**Figure 2.** Risk Factor Report Card.

Task: _____ Work Area: _____ Date: ___/___/___ Reference No.: _____		
Risk Factor	Measurements & Body Parts Affected	Reasons for the Risk Factor
<p><b>1. Poor Posture</b></p> 	<p>How many hours per day: _____</p> <p>How many days per week: _____</p>	
<p><b>2. Heavy or Frequent Lifting</b></p> 	<p>Typical weight handled: _____</p> <p>How many times per day: _____</p>	

**Figure 3.** Portion of a Task Observation Worksheet.

2. The committee chairperson screens the reports to determine if the concern is truly an ergonomics issue and whether or not it can be handled immediately.
3. If more information is needed a committee member is assigned to talk with affected workers about their concerns using data collection tools such as the Task Observation Worksheet (Figure 3).
4. The committee discusses the concern. If it is something that currently has no practical solution, or if it is beyond the abilities of the committee to deal with, the issue is filed for later review and the employee submitting the concern is briefed.
5. An investigative subcommittee is then formed with both committee members *and* employees to assess the concern.
6. When the subcommittee has finished its analysis of the concern, a report is given to the entire committee. If necessary, the committee may decide to collect more information to further define the issue.
7. When the committee feels that the concern has been well defined, it investigates possible interventions. An intervention is chosen based on a number of factors, such as an expected reduction in injuries, a reduction in risk factor exposure, its ease of implementation, and expected productivity improvement. If no intervention is possible the issue is filed for later review and the employee submitting the concern is briefed.
8. After an intervention is introduced, its effectiveness is monitored. A committee member interviews affected workers to see if things are better and if any unexpected problems were created. If it fails to alleviate the concern or causes new ones a new intervention is tried and monitored.

## How the Workforce Is Kept Involved

Keeping the workforce and union involved with the ergonomics process was considered crucial to its success. This was accomplished in several ways:

**Ergonomics Awareness Training** was provided by NIOSH to small groups of employees over a period of several days. Separate training was given to office and field workers. Eventually, the entire workforce attended one-hour sessions covering the following topics:

- What is the Bridger Coal Ergonomics Committee and what is its mission?
- What is ergonomics?
- What are the differences between acute and cumulative injuries?
- What are the signs and symptoms of cumulative injuries?
- The importance of a proactive approach to preventing cumulative injuries
- Basic anatomy of the back and wrist
- Cumulative injury risk factors such as poor posture and repetitive work
- How to identify musculoskeletal disorder risk factors
- Techniques for preventing cumulative injuries, such as engineering and work practice controls, personal protective equipment, and training

The training concluded with a job improvement workshop where the employees practiced identifying risk factors associated with various jobs.

**Risk Factor Report Cards** are readily available to all employees to submit to the committee and serve to remind workers of the importance of being aware of risk factors.

**Posters** are frequently displayed and updated around the mine site highlighting progress on various issues. These also serve to ensure employees that their concerns are being addressed.

**Investigative Subcommittees** are formed when a risk factor report card is submitted and the concern has no immediate solution. Affected employees are given the opportunity to participate on subcommittees assigned to gather information on their concerns. This insures the subcommittees will have input from workers actually performing a job being studied.

## STATUS OF THE BRIDGER COAL ERGONOMICS PROCESS

The process at Bridger Coal has been in operation for approximately one year. It will take several more years for it to evolve and be fully accepted. A plan on how to assess its impact will be developed jointly with NIOSH and Bridger Coal management. However, employees have turned in over forty Risk Factor Report Cards and the ergonomics committee is addressing over a dozen separate issues. Examples of ongoing projects include:

- Handle design on 20 lb. sledge hammers
- Jolting and jarring during ripping tasks with certain dozers
- Manual handling of dragline power cables
- Heavy manual lifting performed by mine service operators while unloading trucks
- Control layout on drilling machines
- Impact resistant gloves for mechanics

There are several projects where interventions have already been introduced by the committee and are being evaluated:

*Water Truck Pump Switches* - Drivers reported that they had to constantly lean over in their cabs and hold their arm in an elevated, extended position to operate the pump switch. The problem was worse in colder weather, when the pumps had to be turned on and off continuously during spot watering to avoid icing up the haul roads. Moving the pump switch to a location near the gearshift tower solved the problem with minimal cost (Figure 4). The new position eliminates constant reaching between the gearshift and the pump switch, reducing the risk



**Figure 4.** The new position of the pump on/off switch near the gearshift lever allows the operators to keep their arms closer to a neutral posture.

of operator error as well as cutting down on awkward posture and repetitive motions.

*Welder Hoods* - Workers reported that the weight of the welder hoods might be causing neck and back pain. After searching for quite some time, the committee found a new style of hood that is significantly lighter and offers the same protection. Initial feedback from the workers has been positive. If continued testing shows the new hood reduces neck and back pain, it will become the standard for the mine.

*Rubber Tired Loading Machine Foot Pedal Design* - Operators indicated that they were experiencing hip, knee and ankle pain while operating the foot pedal on a certain type of loading machine. After studying the problem, the angle of the pedal with the floor was lowered. The operators have reacted very positively to this change, reporting that their hip, knee and ankle pain has been significantly reduced or eliminated.

The Bridger Coal ergonomics committee is carrying out these interventions, with NIOSH serving in a consulting role only. However, two concerns indicated on the report cards have resulted in NIOSH-led efforts for interventions. These interventions will be introduced in a controlled manner, with extensive baseline data collected before the intervention is introduced

and additional data collected for several years after the introduction. This approach will allow the NIOSH researchers to better understand and report on both the effectiveness of the intervention and its method of introduction. The NIOSH intervention projects include:

*Dragline Workstation Design* - Report cards and the mine's injury records indicated that a large percentage of dragline operators (41%) were regularly experiencing shoulder pain. The job requires high levels of repetitive wrist, elbow and shoulder motions to manipulate the dragline's two joystick controls (Figure 5).



**Figure 5.** Dragline operator using joystick controls.

*Powder person tasks* - Information received from supervisors and workers indicate that the powder person crew performs manually intensive work at the mine in rather extreme weather conditions. These include tying the shots, shoveling, taping holes (Figure 6), and awkward postures while loading holes. Some of these tasks will be examined to assess frequency and duration of exposure to a variety to risk factors. Alternatives will be investigated that fit within the context of engineering design, work practices, and personal protective equipment.



**Figure 6.** Pulling tape from the blast hole.

## SUMMARY

An ergonomics process provides a structured framework for workers and employers to identify jobs that could lead to musculoskeletal disorders and to develop solutions that make the work less physically demanding. Increasing their knowledge of ergonomics principles and the application of engineering, administrative, and work practice controls can accomplish this.

Bridger Coal Company, working with its local union and NIOSH, has initiated an ergonomics process at its Rock Springs, Wyoming surface operation. The process is just over one year old and already over one dozen problems have been identified by the workforce and are being addressed by the ergonomics committee.

Over the next several years, NIOSH will continue to monitor the process implemented at Bridger Coal and will develop and evaluate two interventions at the mine. The ergonomics process put in place will facilitate the NIOSH intervention effectiveness evaluation, as well as providing Bridger Coal with a long term means to reduce their worker's exposures to health and safety risk factors.

## REFERENCES

NIOSH [1996]. Results from the National Occupational Survey of Mining (NOHSM). Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication 96-136.

Zhuang Z and Groce D [1995]. The National Occupational Health Survey Of Mining: Magnitude Of Potential Exposures To Musculoskeletal Overload Conditions. In: Bittner AC, Champney PC, eds. *Advances in Industrial Ergonomics and Safety VII*. London: Taylor and Francis, pp. 273-280.

Winn F, Biersner R, and Morrissey S, [1996]. Exposure Probabilities To Ergonomic Hazards Among Miners. In: *International Journal of Industrial Ergonomics*, vol. 18, Elsevier Science, pp. 417-422.

GAO/HEHS-97-163 [1997]. Private Sector Ergonomics Programs. US General Accounting Office, Human Services Division

Cohen A, Gjessing G, Fine L, Bernard B, McGlothlin J, [1997]. *Elements Of Ergonomics Programs: A Primer Based On Workplace Evaluations Of Musculoskeletal Disorders*. U.S. Department of Health and Human Services, CDC, NIOSH.

OSHA [1993]. *Ergonomics Program Management Guidelines For Meatpacking Plants*. Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration, OSHA Report 3123.

# **PROCEEDINGS THIRTY-THIRD ANNUAL INSTITUTE ON MINING HEALTH, SAFETY AND RESEARCH**

**ROANOKE, VIRGINIA  
AUGUST 27 - 30, 2002**

## **Editors**

**George R Bockosh**  
Senior Scientist  
National Institute for Occupational Safety and Health  
(NIOSH)  
Pittsburgh Research Laboratory

**Jeffrey Kohler**  
Research Director  
National Institute for Occupational Safety and Health  
(NIOSH)  
Pittsburgh Research Center

**John Langton**  
Chief, Division of Safety, Coal  
Mine Safety and Health Administration  
U.S. Department of Labor

**Tom Novak**  
Professor and Head  
Department of Mining and Minerals Engineering  
Virginia Tech

**Michael K. McCarter**  
Professor and Chair  
Department of Mining Engineering  
University of Utah

**Angelo Biviano**  
Writing and Communications Program Coordinator  
Department of Mining and Minerals Engineering  
Virginia Tech

## **Sponsors**

Department of Mining and Minerals Engineering  
Virginia Tech

Department of Mining Engineering  
University of Utah

Mine Safety and Health Administration  
U.S. Department of Labor

National Institute for Occupational Safety and Health  
Centers for Disease Control and Prevention

National Mining Association

National Stone, Sand & Gravel Association

Virginia Aggregates Association

Bituminous Coal Operator's Association

Society of Mining, Metallurgy, and Exploration

## **Published By**

Department of Mining and Minerals Engineering  
Virginia Polytechnic Institute and State University  
Blacksburg, Virginia 24060  
(540) 231-6671

TN 295  
.I59  
2002  
C.2