ERGONOMIC INTERVENTIONS AT BADGER MINING CORPORATION

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Abstract

In 2005, NIOSH and Badger Mining Corporation entered a partnership to implement ergonomic interventions, including a systematic process, to address exposures to risk factors that may result in musculoskeletal disorders or other types of injuries/illnesses. As a result of this partnership, an ergonomics process was integrated with the existing safety and health program to promote an on-going application of ergonomic principles, and over 40 task-specific interventions were implemented during the first year of the process. This paper presents details of the process integration, and several examples of task-specific interventions that reduced exposures to risk factors.

Introduction

Badger Mining Corporation is a family-owned small business with its headquarters in Berlin, Wisconsin. Badger operates two sandstone mines near Fairwater and Taylor, Wisconsin, which produce approximately two million tons of industrial silica sand annually. Badger also owns three subsidiary companies, one of which participated in the ergonomics process. This subsidiary (LogicHaul) is located at the Fairwater Mine and is responsible for transportation and distribution of products utilizing trucks and rail cars. There are 180 employees at the Resource Center (headquarters offices), Fairwater, Taylor and LogicHaul.

From 2002 through 2004, the average non-fatal days lost (NFDL) injury incidence rate reported to the Mine Safety and Health Administration was 3.28 injuries per 100 employees for Taylor. Fairwater had no NFDL injuries during this time period. The national average NFDL injury incidence rate for similar type mines (surface mines that mine the same type of commodity) was 2.15. A review of both NFDL and no days lost (NDL) or restricted work day cases occurring during 2003 and 2004 at both sites, indicated that 79 percent of the NFDL injuries (61 of 77) and 85 percent of the NDL injuries (92 of 108) were associated with musculoskeletal disorders (MSDs).

Organizationally, Badger uses a team management structure consisting of work teams and cross-functional teams, who are responsible for setting the work schedule, changing work practices, and providing feedback to the operations team. Members of work teams are cross-trained and may perform many disparate tasks. Work teams are self-directed and are responsible for the safety of their members. Badger associates complete CARE (Corrective Action Request for Evaluation) Reports for all safety incidents including accidents, injuries, property damage, near misses and hazard exposures. Cross-functional teams address functions pertinent to many teams, such as safety and quality. Each site has a separate safety team, which processes the CARE reports and addresses safety-related issues that cannot be resolved by the work teams. Because the mining processes and products are different at the two mines, the members of the two safety teams differ slightly. The Fairwater Safety Team includes 25 members and represents 16 work teams; the Taylor Safety Team includes 28 members and represents 15 work teams. The Safety Associate, a headquarters employee, also serves as a member of the Safety Teams at both mines. The Safety Associate functions as a consultant to the mines and provides training, offers motivational programs, conducts investigations and implements Badger's behavior-based safety (BBS) system, which was initiated in December 2002. BBS observers have been trained to conduct random, periodic observations of employees to identify both safe and unsafe behaviors and to correct unsafe behaviors. Safety observations are documented using a "Do It Safely" form and are conducted at both mines and the Resource Center.

Ergonomics Process Intervention

When integrated with safety and health programs, ergonomics can be viewed as an approach to improve injury and illness rates and the overall working conditions for employees by addressing risk factor exposures that may occur during manual tasks[1]. These exposures are most often associated with musculoskeletal disorders, but may also result in other disorders and illnesses, such as heat stress disorders or vibration-related illnesses. Because Badger decided to integrate fully the application of ergonomic principles with its existing safety program, ergonomic concerns are addressed using the same process as any other safety and health concern, which is shown in Figure 1. Actions to address these concerns are initiated by either a CARE report or a BBS ergonomic observation, which are reviewed by the Safety Team. If the risk factor exposure(s) can be addressed by this team then no further action is needed. However, if the cost of the corrective action exceeds the limits set for the Safety Team, then the concern is transferred to the Operations Team. Since the Safety Team includes members of the Operations Team, this transfer is seamless. The champion for the Badger ergonomics process is the Safety Associate.

With a decentralized safety and health process, Badger initiated its ergonomics process by training all employees in February 2005. The training, which was 2.5 hours, was given by NIOSH and emphasized identifying risk factor exposures and then reporting those exposures using a CARE report so corrective actions could be instituted to resolve the exposures. This training also included a brief introduction to ergonomics and musculoskeletal disorders, with specific information on back injuries and how the risk of injury could change based on methods used to perform lifting tasks. Examples of risk factor exposures were illustrated with short videos of tasks performed at either Badger mine. Training techniques included interactive exercises and demonstrations. To ensure the participation of new associates in the ergonomics process, Badger provides ergonomics and risk factor awareness training during new associate orientation; and to keep associates involved in the ergonomics process, interactive exercises demonstrating ergonomics principles are included in annual refresher training.

Because Badger utilizes a behavior-based safety system as part of its overall safety and health program, it was decided to also incorporate ergonomic observations into this system for the purpose of identifying and eliminating exposures to risk factors. The primary focus of a BBS system is to decrease injury rates by preventing unsafe behaviors, which is accomplished by implementing a systematic process of data collection,

[1] Manual tasks include any activity requiring the worker to grasp, manipulate, strike, throw, carry, move, hold or restrain an object, load or body part.

often achieved with observations, and correction of unsafe behaviors (Krause, 2002). Sulzer-Azaroff and Austin (2000), who reviewed articles describing the results of implementing BBS systems, reported that 32 of 33 BBS systems reviewed resulted in reductions in injuries. However, none of these systems reported results specific to musculoskeletal disorders. Although the top three US automakers do not integrate their ergonomics processes with their BBS systems, other automotive companies, Toyota and Tenneco Automotive, have done so. In these two companies, BBS systems were used to identify musculoskeletal problems and direct potential solutions (Knapschaefer, 1999).

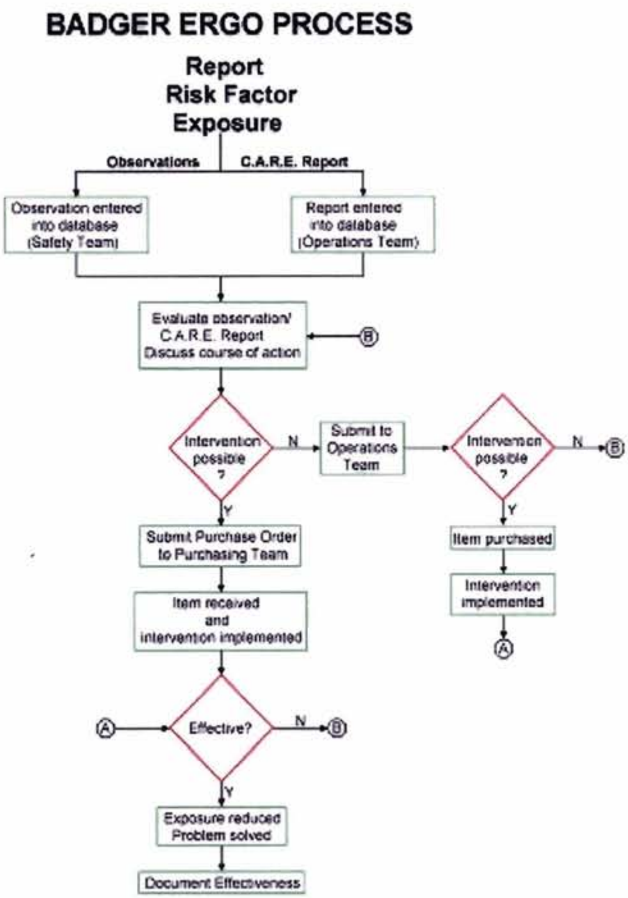

Figure 1. Ergonomics Process Flow Diagram

Although ergonomics was initially included in the Badger BBS system as a hazard that was either present or not present, the information gathered during observations was not sufficient to either identify specific risk factor exposures or control exposures not related to unsafe behaviors. For example, a person may use an awkward posture to do a task not because of an unsafe behavior but instead because the layout of the workstation results in the worker using an awkward posture. Typically, the observation of this unsafe behavior would result in training the worker not to use an awkward posture; however, because the awkward posture is a result of the workstation layout and not a choice of method/behavior, further efforts are needed to resolve the risk factor exposures. In other words, observers require information on how to modify tasks, equipment, tools, workstations, environments and methods using a hierarchal approach to controlling exposures (engineering controls, administrative controls and personal protective equipment), with engineering controls being the preferred control measure (Chengalur, et al, 2004). Consequently, it was necessary to provide BBS observers with training on not only identifying specific risk factor exposures, but also on how to control these exposures.

Training was provided to the BBS observers at both the Fairwater and Taylor Mines in July 2005 that focused on identifying risk factor exposures and also providing them with simple ways to reduce or eliminate exposures associated with manual material handling. The training followed the observation process the observers used to conduct safety observations and included role-playing exercises to allow the observers to be comfortable when doing ergonomic observations. To document risk factor exposures, an Ergonomic Observation Form was developed that also included simple ways to improve tasks. Information collected with this form includes risk factor exposures, body discomfort, root causes of the exposures, and corrective actions taken at the time of the observation. Practice completing the Ergonomic Observation Form was provided during the role-playing exercises.

In June 2006, additional training was provided to the BBS observers. This training consisted of a review of risk factors and then additional practice at identifying risk factor exposures by viewing short videos and observing work tasks during field exercises. Methods to improve jobs were also discussed. Members of the Safety Teams also attended this training since these teams resolve observations not immediately addressed by the observers and CARE reports.

From August 2005 through May 2006, the BBS observers at both the Fairwater and Taylor Mines completed approximately 30 ergonomic observations. During ten of the observations, the risk factor exposures were either resolved or job improvements were identified. The job improvements included personal protective equipment (anti-vibration gloves), training on how to do a particular task without exposures to awkward postures, and engineering controls. Two examples of engineering controls included raising the work surface with saw horses, which allowed the use of neutral postures, and constructing a hand tool to open covers on rail cars, which eliminated flexion of the trunk and reduced the forceful exertion needed to release the latch.

Task-Specific Interventions

Within one year of implementing its ergonomics process, Badger implemented over 40 interventions, which are described in Tables 1 and 2 (see Appendix A). Some of these interventions were planned prior to initiating the ergonomics process; however, information gained from the training led to improvements from the original design. All but a few of the improvements were engineering controls, and many of them involved obtaining new equipment or workstations. Some of the modifications to workstations or equipment were completed by the equipment maintenance staff, and did not result in significant expenditures of funds or time. Examples of the interventions include:

Cable Cutter - Problem: Electricians identified cutting copper wire (multi-strand, 600 volt, with an outer diameter of 0.875 inches) with a manual wire cutter (Figure 2a) as a highly repetitive task combined with forceful exertions. **Solution:** Since the task could not be eliminated, it was important to find a reasonable intervention that would reduce the risk factor exposures. The intervention chosen was a cable cutter, which attaches to any power drill (Figure 2b). Minimal force is exerted to operate the drill and the wire is cut in seconds. The cost of the cable/wire cutter attachment was $500.

a. b.

Figure 2. Manual (a) and power (b) cable cutters.

Parts Washer - Problem: Mechanics routinely cleaned equipment parts, tools, and chains that were greasy, oily, and dirty by using chemical solvents to break down the grease and oil before manually scrubbing the part. This task involved exposures to forceful exertions, repetition, and awkward postures. The amount of time required to clean parts significantly increased the risk associated with these risk factor exposure. For example, manually cleaning parts for a loader undergoing winter repairs took approximately forty hours. **Solution:** To address these exposures, an automatic parts washer was purchased for approximately $6000.00. Not only has the automatic parts washer effectively reduced the risk factor exposures, but productivity of the equipment maintenance team increased since the mechanics are now able to complete repair work as the parts are cleaned by the washer.

<u>Scale</u> - **Problem:** To verify accurate filling of 100-pound bags, a sampling of bags were lifted from the conveyor and weighed on a scale located on the floor near the conveyor (Figure 3a). This task resulted in exposures to forceful exertions and awkward postures. **Solution**: To reduce these risk factor exposures, the scale was placed on an elevated cart so it could be moved closer to the conveyor and the lift could be performed between knee and shoulder height (Figure 3b). The cost of the cart was less than $100.

Figure 3. Scale to weigh bags was moved from the floor (a) to a cart (b).

<u>Screen Covers</u> - **Problem:** To maintain the screens in the screen house, the covers, which weigh 30 to 40 pounds, were removed by lifting and then placing them to the side of the screen housing, resulting in exposures to forceful exertions and awkward postures (Figure 4a). **Solution:** New covers were fitted with gas struts, so they can now be easily opened with one hand (Figure 4b). Exposures to both risk factors were eliminated. The average costs associated with this intervention included $800-1000 for parts (hinges, clamps and gas cylinders) per cover, and $1000 for the engineering design per cover design. Labor for installing the new covers was done by the maintenance department.

Figure 4. Old screen cover being removed from housing (a) and new screen cover retrofitted with gas struts (b).

<u>Automatic Actuators</u> - **Problem:** To maintain the actuator, internal orifice plates needed to be removed and replaced when they became clogged with wet sand (Figure 5a). Completing this task once a shift resulted in exposures to awkward postures (excessive reaching and leaning forward) and climbing four flights of stairs. **Solution:** Installing an automatic actuator eliminated the need to manually maintain it and the awkward postures, as well as climbing the stairs (Figure 5b). The cost of the automatic actuator was $500 plus labor.

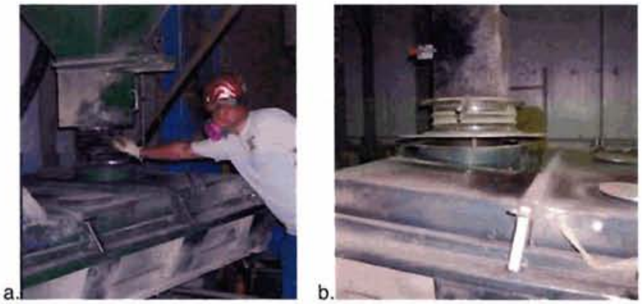

Figure 5. Manually resetting actuator (a) and automatic actuator (b).

<u>Rail Car Cover Latch Tool</u> - **Problem:** To open the rail car cover, the associate used his foot to release the latch while bending over to open the cover (Figure 6a). This task is done every day, 8 times per shift. Associates have experienced hip and back discomfort. **Solution:** Two hand tools were constructed by the Maintenance Team to unlatch different types of covers. The associate kneels on one knee as he places the tool on the latch and then pushes down on the tool with his arm to release the latch. Once the latch is released, the cover is opened (Figure 6b). Although the associate is still exposed to an awkward posture, briefly kneeling on one knee probably results in less risk than the trunk flexion used when not using the hand tool. The material used to fabricate the two tools was available scrap material so the only cost associated with this intervention was for labor.

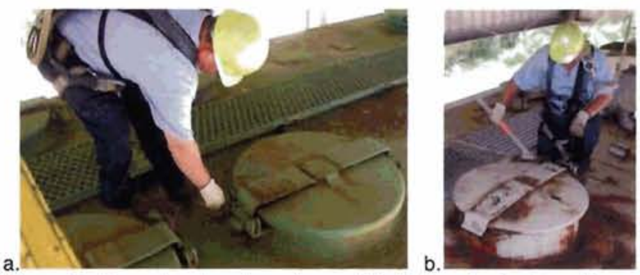

Figure 6. Manually releasing rail cover latch (a) and releasing rail cover latch with hand tool (b).

The interventions completed by Badger were identified and implemented by Badger's self-directed work teams. Associates applied knowledge they gained during the Ergonomics and Risk Factor Awareness Training to the tasks their teams performed. Although this approach was very effective in achieving results within each team, it is not clear if the tasks with the greatest risk factor exposures were addressed. To address risk factor exposures based on risk, a prioritization scheme was developed which categorizes exposures as low, medium, or high risk. The prioritization scheme is applied by the Safety Teams and indicates which tasks should receive priority in terms of investigations and interventions.

Conclusions

The process being implemented at Badger is proactive as it addresses exposures to risk factors and not just injuries. During the first year of this process, the emphasis has been on addressing CARE reports and BBS ergonomic observations. However, information learned by the associates during the Ergonomics and Risk Factor Awareness Training was also applied to the design of new work areas and facilities. Badger's process is participatory and as it matures will move to a more comprehensive process with the incorporation of ergonomic principles into more processes that affect employee safety and health.

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Disclaimer

The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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Appendix A

Table 1. Description and type of interventions completed by Badger Mining Corporation - Fairwater.

TYPE OF INTERVENTION	NUMBER OF ASSOCIATES AFFECTED	BRIEF DESCRIPTION OF INTERVENTION
Existing equipment or workstation modified	3	– Mirrors installed on track mobiles
		– Asphalt applied to unpaved roads
		– Powered loading dock ramp replaced manual placement of dock ramp
	6	– Automatic actuators installed in screen house replaced the requirement to manually reset actuators
New workstations purchased or constructed	3	– Truck scale with washout system replaced manual clean out while standing in a pit
		– Rail load-out canopy eliminated stooping under low hanging equipment and improved fall protection
New equipment purchased or constructed	3	– Brake stick used for rail cars instead of climbing on rail car and manually setting brake
	3	– Floor mats purchased for dry plant
	4	– Automatic greaser replaced manual grease guns
		– Electric tarps replaced manual tarps on dump trucks
	4	– Man lift replaced ladders
		– Automatic dust collection screw replaced manually pounding on the hoppers
	3	– Tool to unlatch rail covers replaced manually unlatching the covers with hands
New seats purchased	1	– New office chairs replaced existing chairs
	2	– Air-ride seat installed in haul truck

Table 2. Description and type of interventions completed by Badger Mining Corporation - Taylor.

TYPE OF INTERVENTION	NUMBER OF ASSOCIATES AFFECTED	BRIEF DESCRIPTION OF INTERVENTION
Existing equipment or workstation modified	6	- Rail clean out facility modified to allow a standing posture rather than a stooped/squatting posture
	16	- Modified dozer operator compartment
	16	- Smaller 2.5-gallon pails for drilling samples replaced 5.0-gallon pails
		- Ramp leading into pit was widened
	16	- Haul roads were straightened
	16	- Ride control installed on new loaders
	16	- Air flow in dryer-pipe revamped
Workstation rearranged	5	- Tools placed in tool buckets so weight is evenly distributed
New workstations purchased or constructed	5	- Raised (waist-height) workstation built for constructing bucket elevators
New equipment purchased	6	- Hy-vac truck purchased for rail clean-out replaced manual shoveling
	6	- 2-inch hose on Hy-vac replaced heavy 4-inch hose
	6	- Brake stick used for rail cars instead of climbing on rail car and manually setting brake
	6	- Rail cars with light weight hatches replaced rail cars with heavy metal covers
	7	- Auto samplers installed in dry house replaced manual collection of samples
	2	- Telephone head-set purchased for receptionist
	5	- Drills purchased for bucket elevator construction
	5	- Shock-absorbing hammers replaced regular hammers
	5	- Anti-fatigue mats were placed in heavy traffic areas of the shop
	5	- Wagons built to transport tools instead of carrying tools
	1	- Cable cutter attachment for drill replaced manual cutter
		- New pick-up trucks replaced Army surplus vehicles
	5	- Electric grease guns replaced manually-operated grease guns
	7	- Elevator installed in new dry plant replaced the need to climb stairs while carrying tools
	5	- Parts washer replaced manual washing of parts
	6	- Hinged screen covers replaced covers that had to be manually lifted off the screen housing
New seats purchased	16	- Replaced seat in drill
Elimination of equipment	6	- Rail cars with trough hatches were removed from service
Work practice modified		- Modified method to open bulk bags to eliminate stooping and leaning into bag
Personal protective equipment	5	- Anti-vibration gloves purchased for constructing bucket elevators
	5	- Welding helmets with auto-darkening lens replaced helmets with regular dark lens
	5	- Shoe in-soles provided to maintenance workers