Ergonomics Interventions at Badger Mining Corporation

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In 2005, the National Institute for Occupational Safety and Health (NIOSH) and Badger Mining Corporation entered a partnership to implement ergonomics interventions, including a systematic process, to address exposure 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 programme to promote an on-going application of ergonomics 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 exposure to risk factors.

1. INTRODUCTION

Badger Mining Corporation is a family-owned small business with its headquarters in Berlin, WI, USA. Badger operates two sandstone mines near Fairwater and Taylor, WI, USA, which produce ~1.82 billion tonnes 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 nonfatal 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 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% of the NFDL injuries (61 of 77) and 85% of the NDL injuries (92 of 108) were associated with musculoskeletal disorders (MSDs).

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Organizationally, Badger used a team management structure consisting of work teams and cross-functional teams, who were responsible for setting the work schedule, changing work practises and providing feedback to the operations team. Members of work teams were cross-trained and could perform many disparate tasks. Work teams were self-directed and were responsible for the safety of their members. Badger associates completed CARE (Corrective Action Request for Evaluation) reports for all safety incidents including accidents, injuries, property damage, near misses and hazard exposure. Cross-functional teams addressed functions pertinent to many teams, such as safety and quality. Each site had a separate safety team, which processed the CARE reports and addressed safety-related issues that could not be resolved by the work teams. Because the mining processes and products were different at the two mines, the members of the two safety teams differed slightly. The Fairwater safety team included 25 members and represented 16 work teams; the Taylor safety team included 28 members and represented 15 work teams. The safety associate, a headquarters employee, also served as a member of the safety teams at both mines. The safety associate functioned as a consultant to the mines and provided training, offered motivational programmes, conducted investigations and implemented Badger's behaviour-based safety (BBS) system, which was initiated in December 2002. BBS observers were trained to conduct random, periodic observations of employees to identify both safe and unsafe behaviours and to correct unsafe ones. Safety observations were documented using a Do It Safely form and were conducted at both mines and the Resource Center.

2. ERGONOMICS PROCESS INTERVENTION

When integrated with safety and health programmes, ergonomics can be viewed as an approach to improve injury and illness rates and the overall working conditions for employees by addressing risk factor exposure that may occur during manual tasks[1]. This exposure is most often associated with MSDs, 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 ergonomics principles with its existing safety programme, ergonomics concerns were addressed using the same process as any other safety and health concern (Figure 1). Actions to address these concerns were initiated by either a CARE report or a BBS ergonomics observation, which were reviewed by the safety team. If the risk factor exposure(s) could be addressed by this team then no further action was needed. However, if the cost of the corrective action exceeded the limits set for the safety team, then the concern was transferred to the operations team. Since the safety team included members of the operations team, this transfer was seamless. The champion for the Badger ergonomics process was 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 hrs, was given by the National Institute for Occupational Safety and Health (NIOSH) and emphasized identifying risk factor exposure and then reporting that exposure using a CARE report so corrective actions could be instituted to resolve the exposure. This training also included a brief introduction to ergonomics and MSDs, 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 provided ergonomics and risk factor awareness training during new associate orientation; and to keep associates

[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.

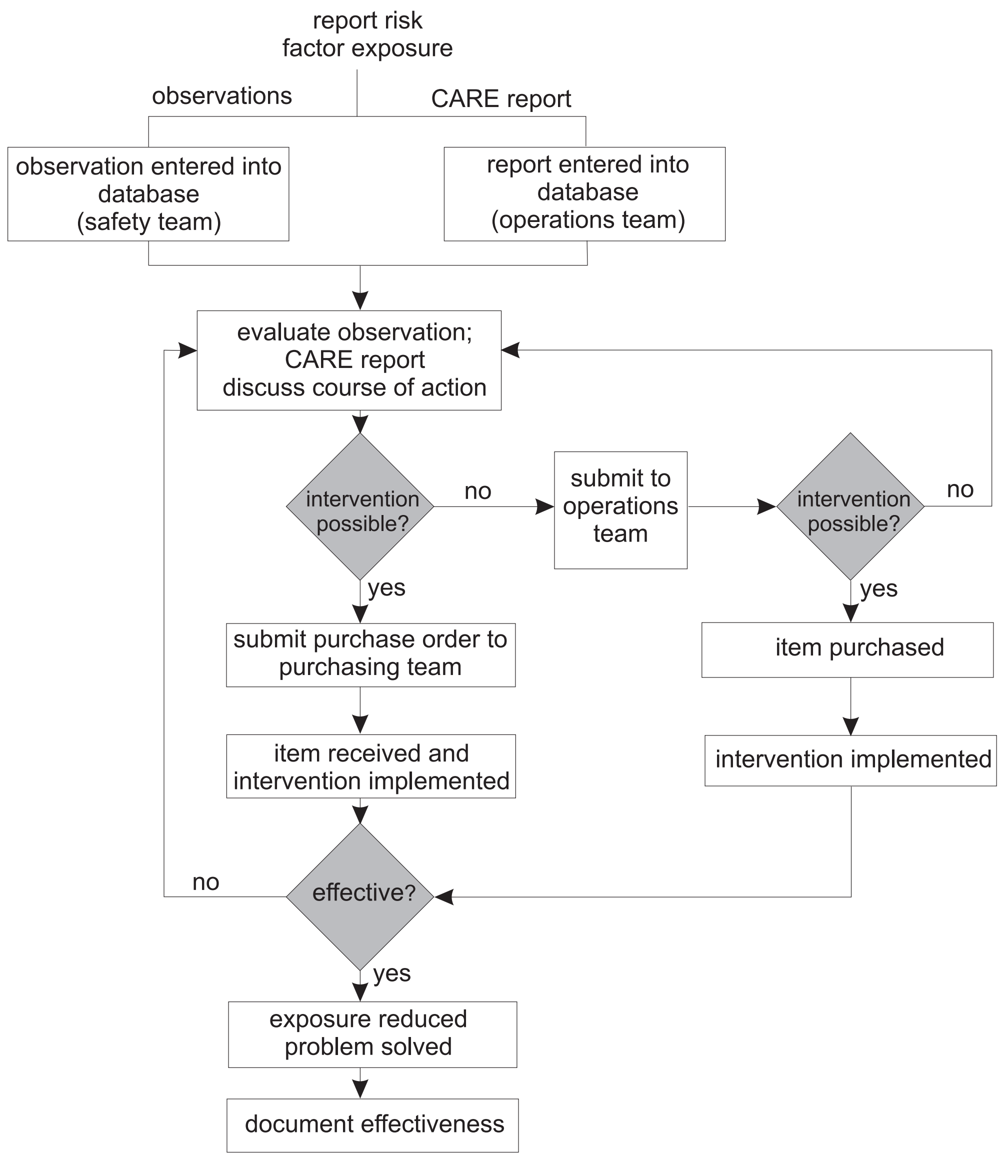

Figure 1. Badger ergonomics process diagram. *Notes*. CARE—Corrective Action Request for Evaluation.

involved in the ergonomics process, interactive exercises demonstrating ergonomics principles were included in annual refresher training.

Because Badger utilized a behaviour-based safety system as part of its overall safety and health programme, it was decided to also incorporate ergonomics observations into this system for the purpose of identifying and eliminating exposure to risk factors. The primary focus of a BBS system was to decrease injury rates by preventing unsafe behaviours, which was accomplished by implementing a systematic process of data collection, often achieved with observations and correction of unsafe behaviours [1]. Sulzer-Azaroff and Austin [2], 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 MSDs. Although the top three U.S. 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 [3].

Although ergonomics was initially included in the Badger BBS system, it only identified ergonomics issues as hazards that were present during the observations. Specific risk factor exposures were not identified, and exposures that were not related to unsafe behaviours could not be corrected. For example, a person could use an awkward posture to do a task not because of an unsafe behaviour but because the layout of the workstation resulted in the worker using an awkward posture. Typically, the observation of this unsafe behaviour would result in training the worker not to use an awkward posture; however, because the awkward posture was a result of the workstation layout and not a choice of method/behaviour, further efforts were needed to resolve exposure to the risk factor. In other words, observers required information on how to modify tasks, equipment, tools, workstations, environments and methods using a hierarchal approach to controlling exposure (engineering controls, administrative controls and personal protective equipment), with engineering controls being the preferred control measure [4]. Consequently, it was necessary to provide BBS observers with training on not only identifying a specific risk factor exposure, but also on how to control that exposure.

Training was provided to the BBS observers at both the Fairwater and Taylor mines in July 2005; it focused on identifying risk factor exposures and also provided them with simple ways to reduce or eliminate exposure 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 ergonomics observations. To document risk factor exposures an ergonomics observation form was developed; it also included simple ways to improve tasks. Information collected with this form included risk factor exposures, body discomfort, root causes of the exposures and corrective actions taken at the time of the observation. Practise completing the form was provided during 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 practise 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 ~30 ergonomics observations. During 10 of them, the risk factor exposure was either resolved or job improvements were identified. The job improvements included personal protective equipment (antivibration gloves), training on how to do a particular task without exposure to awkward postures and engineering controls. Two examples of engineering controls included raising the work surface with saw horses, which made neutral postures possible, 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.

3. TASK-SPECIFIC INTERVENTIONS

Within one year of implementing its ergonomics process, Badger implemented over 40 interventions (Tables 1–2). Some of them were planned prior to initiating the ergonomics process; however, information gained from the training led to improvements in 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 expenditure of funds or time. Examples of the interventions are discussed in sections 3.1.–3.6.

TABLE 1. Description and Type of Interventions Completed by Badger Mining Corporation, Fairwater, WI, USA

Type of Intervention	No. of Associates Affected	Brief Description of Intervention
Existing equipment or workstation modified	3	Mirrors on track mobiles
		Asphalt on unpaved roads
	—	Powered in lieu of manual loading dock ramp
	6	Automatic in lieu of manual actuators in screen house
New workstations purchased or constructed	—	Truck scale with washout system in lieu of manual clean-out in a pit
	3	Rail load-out canopy to eliminate stooping under low hanging equipment and to improve protection against falls
New equipment purchased or constructed	3	Brake stick for rail cars in lieu of the need to climb on rail car and manually set brake
	3	Floor mats for dry plant
	4	Automatic in lieu of manual grease guns
	—	Electric in lieu of manual tarps on dump trucks
	4	Elevator in lieu of ladders
	—	Automatic dust collection screw in lieu of manual pounding on the hoppers
	3	Tool to unlatch rail covers in lieu of manual unlatching
New seats purchased	1	New office chairs
	2	Air-ride seat in haul truck

TABLE 2. Description and Type of Interventions Completed by Badger Mining Corporation, Taylor, WI, USA

Type of Intervention	No. 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	9.5- in lieu of 19-L pails for drilling samples
	16	Wider ramp leading into pit
	16	Straighter haul roads
	16	Ride control on new loaders
	—	Revamped air flow in dryer pipe
Workstation rearranged	5	Tools in tool buckets so weight is evenly distributed
New workstations purchased or constructed	5	Raised (waist-height) workstation for constructing bucket elevators
New equipment purchased	6	Hy-vac truck for rail clean-out in lieu of manual shoveling
	6	5- in lieu of 10-cm hose on Hy-vac
	6	Brake stick for rail cars in lieu of manually-operated brake
	6	Rail cars with light-weight in lieu of heavy metal hatches
	7	Auto samplers in dry house in lieu of manual collection of samples
	2	Telephone head-set for receptionist
	5	Drills for bucket elevator construction
	5	Shock-absorbing hammers in lieu of regular ones
	5	Antifatigue mats in heavy traffic areas of the shop
	5	Wagons for transporting tools
	1	Cable cutter attachment for drill in lieu of a manual one
	—	New pick-up trucks in lieu of Army surplus vehicles

TABLE 2. (*continued*)

Type of Intervention	No. of Associates Affected	Brief Description of Intervention
New equipment purchased	5	Automatic in lieu of manual grease guns
	7	Elevator in new dry plant in lieu of stairs
	5	Parts washer in lieu of manual washing
	6	Hinged screen covers in lieu of manual ones
New seats purchased	16	New seat in drill
Elimination of equipment	6	Rail cars with trough hatches removed from service
Work practise modified		Modified method of opening bulk bags to eliminate stooping and leaning
Personal protective equipment	5	Antivibration gloves for constructing bucket elevators
	5	Welding helmets with auto-darkening in lieu of regular dark lens
	5	Shoe in-soles for maintenance workers

3.1. Cable Cutter

3.1.1. Problem

Electricians identified cutting copper wire (multi-strand, 600 V, with an outer diameter of 2.2 cm) with a manual wire cutter (Figure 2a) as a highly repetitive task combined with forceful exertions.

(a)

(b)

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

3.1.2. 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 USD.

3.2. Parts Washer

3.2.1. 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 exposure to forceful exertions, repetition and awkward postures. The time required to clean parts significantly increased the risk associated with exposure to these risk factors. For example, manual cleaning parts for a loader undergoing winter repairs took ~40 hrs.

3.2.2. Solution

To address this exposure, an automatic parts washer was purchased for ~6000 USD. Not only did the automatic parts washer effectively reduce exposure to this risk factor, but productivity of the equipment maintenance team increased since the mechanics were able to complete repair work as the parts were cleaned by the washer.

(a) (b)

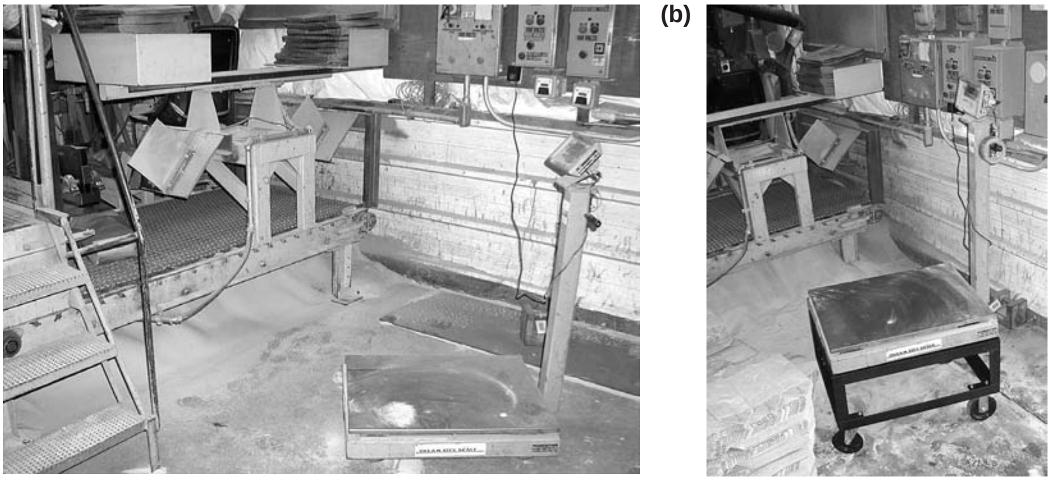

Figure 3. Scale to weigh bags raised (a) from the floor (b) to a cart.

3.3. Scale

3.3.1. Problem

To verify accurate filling of 45.5-kg bags, a sampling of bags was lifted from the conveyor and weighed on a scale located on the floor near the conveyor (Figure 3a). This task resulted in exposure to forceful exertions and awkward postures.

3.3.2. Solution

To reduce exposure to these risk factors, 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 cart was less than 100 USD.

3.4. Screen Covers

3.4.1. Problem

To maintain the screens in the screen house, the covers, which weigh 14–18 kg, were removed by lifting and then placing them to the side of the screen housing, resulting in exposure to forceful exertions and awkward postures (Figure 4a).

(a) (b)

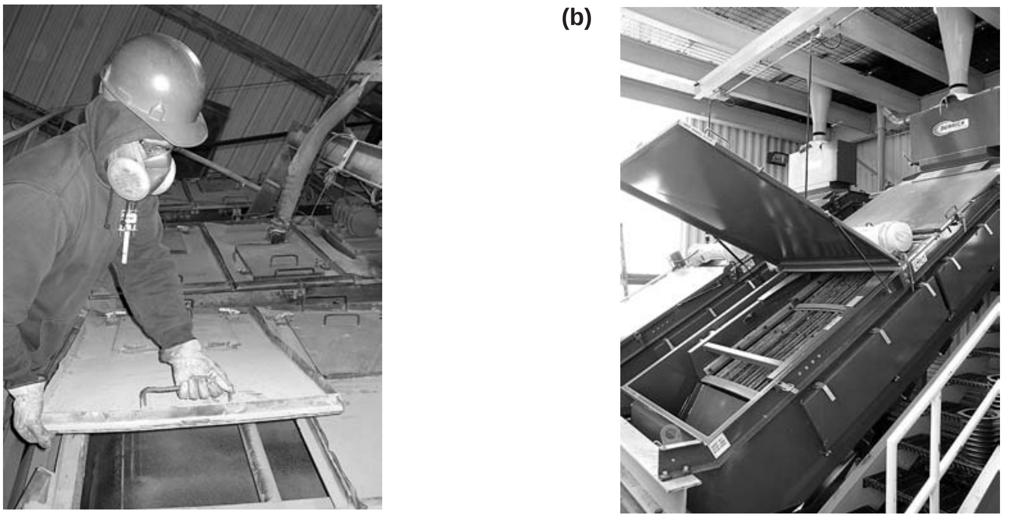

Figure 4. (a) Old screen cover removed from housing, (b) new screen cover retrofitted with gas struts.

3.4.2. Solution

New covers were fitted with gas struts, so they could now be easily opened with one hand (Figure 4b). Exposure to both risk factors was eliminated. The average cost associated with this intervention included 800–1 000 USD for parts (hinges, clamps and gas cylinders) per cover, and 1 000 USD for the engineering design per cover design. The maintenance department installed the new covers.

3.5. Automatic Actuators

3.5.1. 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 exposure to awkward postures (excessive reaching and leaning forward) and climbing four flights of stairs.

3.5.2. Solution

Installing an automatic actuator eliminated the need to manually maintain it, the awkward postures as well as climbing the stairs (Figure 5b). The automatic actuator was 500 USD plus labor.

3.6. Rail Car Cover Latch Tool

3.6.1. 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 was

(a)

(b)

Figure 5. (a) Manually reset actuator, (b) automatic actuator.

(a)

(b)

Figure 6. Rail cover latch released (a) manually and (b) with a hand tool.

done every day, 8 times per shift. Associates experienced hip and back discomfort.

3.6.2. Solution

Two hand tools were constructed by the maintenance team to unlatch different types of covers. The associate kneeled on one knee as he placed the tool on the latch and then pushed down on the tool with his arm to release the latch. Once the latch was released, the cover was opened (Figure 6b). Although the associate was still exposed to an awkward posture, briefly kneeling on one knee probably resulted in less risk than the trunk flexion when the hand tool was not used. The material used to fabricate the two tools was available scrap material so the only cost associated with this intervention was for labor.

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 exposure were addressed. To address risk factor exposure based on risk, a prioritization scheme was developed which categorized exposure as low-, medium- or high-risk. The prioritization scheme was applied by the safety teams and indicated which tasks should receive priority in terms of investigations and interventions.

4. CONCLUSIONS

The process implemented at Badger was proactive as it addressed exposure to risk factors and not just injuries. During the first year of this process, the emphasis was on addressing CARE reports and BBS ergonomics 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 was participatory and as it matured would move to a more comprehensive process with the incorporation of ergonomics principles into more processes that affect employee safety and health.

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