Ergonomic interventions at Unimin

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Abstract
In 2004, management at Unimin's Gleason, Tennessee, operation began implementing ergonomic interventions specifically targeted to reduce the risk of musculoskeletal injuries (MSIs). Together with corporate and site management, Unimin identified worksite hazards and began to modify work practices and equipment. Some interventions were relatively simple and were implemented immediately. Others, such as improvements to a mobile shredder, were more complex but were eventually resolved through a participatory approach with employees, management, manufacturers and NIOSH. This paper discusses ergonomic interventions that were successfully implemented using a participatory approach to reducing the risk of injury.

Introduction
Unimin is an industrial minerals mining company with more than 100 operations worldwide. Unimin produces ball clay, silica, kaolin clay, dolomite, nepheline syenite and olivine. The Gleason, Tennessee, site is a ball clay surface mining facility and a processing facility. Ball clay is a product used mostly for ceramic fixtures and as a bonding agent in ceramic ware. When compared to many other Unimin mines, the Gleason site was experiencing a higher percentage of MSIs (categorized as sprains and strain injuries in an injury database generated by Unimin) for the period of 2000 through 2006. During that period, MSIs accounted for 44% of all reported incidents at Gleason, compared to 26% for all of Unimin. The management team at Gleason continuously searched for means to improve the working environment. To identify improvements that would have the most dramatic impact on MSIs, the management team approached miners individually and discussed their concerns and thoughts on work practices that required significant physical exertion or were repetitive.

While a more formal program of integrating an ergonomics program was available to Unimin, the company chose to implement specific training related to their concerns with an aging workforce. This specific training was given to Unimin's Gleason mine safety and health supervisor by NIOSH researchers. The "Age Awareness Training," described below, was then given to the workforce at biweekly safety meetings until all the modules were addressed. The goal was to empower the employees with knowledge, understanding and application of principles related to reducing musculoskeletal injuries in the workplace. This resulted in ergonomic principles being incorporated into the established safety processes at Gleason. Under the guidance of NIOSH researchers several significant interventions were successfully implemented, which are described in the next section. The training itself was a successful intervention. The goal of this collaboration was to develop interventions to reduce the likelihood of injuries resulting from awkward postures or excessive forces.

Intervention process
While NIOSH researchers visited two Unimin sites prior to implementing the training, several jobs were observed for work related musculoskeletal risk factors. These jobs or tasks were identified by NIOSH and Unimin safety officials as physically challenging, most likely contributing to cumulative injury and/or affecting a large number of employees. An analysis of injuries obtained through the Mine Safety and Health Administration (MSHA) injury database revealed that greater than 40% of the Gleason site's injuries were cumulative in nature. Unimin was interested in redesigning or eliminating those tasks that were contributing to these injuries. These improvements served as a catalyst for motivating employees to make additional changes when the training was introduced. For each of the following interventions, a systematic process was used.

A similar process was successfully used in the work documented by Torma-Krajewski et al. (2007). The general process was to determine which part or parts were contributing the most to the risk of injury, involve the workers in the discovery and solution brainstorming process, redesign the task/equipment,

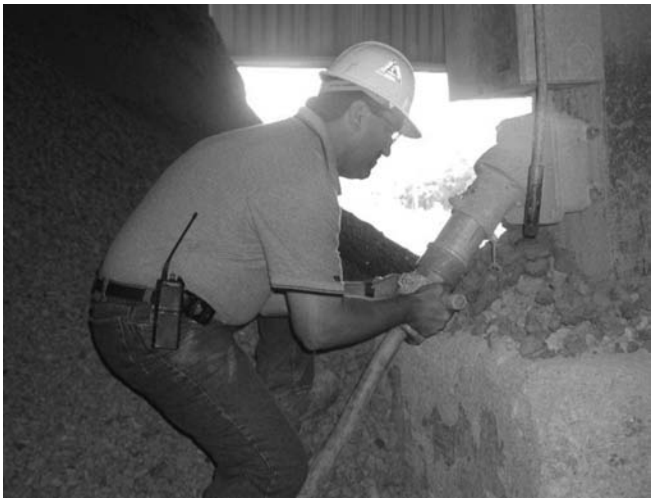

Figure 1 — Mineworker demonstrates power connection.

Figure 2 — The rubber "boot" to protect the male cable connector from dirt, dust and damage.

implement the intervention, evaluate the intervention for its ability to reduce risk factors while minimizing introduction of new risk factors, and sharing success with other Unimin sites. The choice to implement a solution was determined based on worker injury and discomfort reports, number of employees affected, ease and cost of solution and timeliness. A solution was considered successful if it reduced the associated risk factors, eliminated that portion of the task, was accepted and determined successful by employees or if it resulted in reduced injuries. While in many cases it may take several years to see injury rate reductions, Unimin reported reductions in injury rate for this site after 18 months. Evaluation of the job post intervention was the immediate measure of the success in reducing injury risk factors such as awkward postures, forceful exertions, repetition and vibration. The following section summarizes each intervention including a brief description of the task and intervention discovery process.

Interventions

Shredder power cable connector. Due to the nature of ball clay, some unusual equipment is required to process it, such as a clay shredder, which shreds raw clay and disperses it onto a stockpile. The shredders used at Gleason are mobile and, on average, are moved twice daily using a front-end loader. Each time the shredder is moved it must be connected/disconnected to a power source. Because the connector weighs 9 kg (20 lbs) and is difficult to handle, forceful exertions and awkward postures occur when performing this task.

During discussions with the employees, Gleason mine management became aware of difficulties in connecting and disconnecting the shredder power cable (Fig. 1). Issues of concern included:

- the aluminum sleeve became bent, which made it difficult to connect and disconnect from the receptacle;
- hardened and built-up clay on the connectors made it difficult to insert into the receptacle;
- dust on the aluminum sleeve made it more difficult to connect; and
- awkward postures (rounded back, arm position with respect to the body and standing on uneven ground) occurred when connecting and disconnecting the cable to the power source.

Based on the above issues, a possible solution of using an off-the-shelf cable connector was considered. Features of this connector were its light weight, 2.4 kg (5.2 lbs), and its ability to form an easier connection — it had concealed components that remained hidden until the connection was made, which kept the male end free of dirt and debris. The connector also eliminated arc flash exposure and had an accessory tool especially designed to aid in connecting/disconnecting. A significant capital investment was needed to purchase the male/female connectors and the accessory tool and to install all related equipment.

Mine management obtained a sample of the parts necessary for installing the new connector from an equipment vendor. They, in turn, asked nearby mines regarding any experience their operations had in using this type of connectors. The feedback received from the other operations was negative — the external recessed areas of the connectors became clogged with clay particles, and if excessive force was used when making a connection, parts of the connector easily bent. Based on this feedback and a potential capital investment of more than $11,000, the mine management rejected the new connector option.

Subsequently, mine management came up with other options in conjunction with maintenance personnel and shredder operators. This resulted in the following actions:

- A rubber boot (Fig. 2) for the aluminum sleeve was installed on the male end to prevent the sleeve from bending and to keep it clean. The rubber boot was made from a protective cover for a dust collector cartridge that the mine normally stocks.
- An electric grinder was used to file burrs on the inside of the connectors to make insertion of the plug easier.
- A spray lubricant, commonly known as "Super Slick," was applied to the contacts and sleeve of the connector to reduce friction when inserting the connector into the receptacle.

The shredder power cable connector intervention is summarized in Table 1. The Gleason mine safety and health supervisor

Table 1 — Target task: Shredder power cable connector.

Primary risk factors

- Forceful exertions.
- Awkward postures, in particular, a rounded-back arm position with respect to the body and standing on uneven ground.

Root cause

Connector becomes dirty and bent, which increases the difficulty plugging and unplugging the connectors.

Improvement description

- Added a rubber boot to the aluminum sleeve to keep it clean and prevent bending.
- An electric grinder was used to file burrs on the inside of the connectors to make insertion of the plug easier.
- A spray lubricant was applied to the contacts and sleeve of the connector to reduce friction when inserting the connector receptacle.

Figure 3a — Shredder cable haphazardly overlapped.

Figure 3b — Shredder cable evenly looped.

estimated the cost of this intervention as $500 in materials and worker hours. The supervisor indicated that the "employees liked the results" and described the intervention process and outcome as "very good."

Cable handling. Another issue associated with the shredder was how to minimize injury risk when handling the power cable. The specific components of this task included unraveling the cable from its storage device, holding the connector and dragging the cable to and from the power source receptacle and then placing the cable back on the machine in preparation for another move.

Initially, a mechanized cable reel was considered as an option to reduce the physical cable handling. A cable reel manufacturer was enlisted to assist with this option. Given the available space to mount the reel within the frame of the shredder, an initial design was developed and supplied to mine management. One major limitation of the power reel was that, although it provided cable retrieval capability, employees would still have to pull the cable off the reel to connect it to the power source. Also, an estimated cost of the power reel solution for four shredder machines exceeded $38,000. After considering the limitations and costs of the power cable reel, mine management rejected this option.

Afterwards, the mine management team considered a low-cost and simple solution to the cable-handling issue offered by an off-shift shredder operator who was listening to the conversation between the NIOSH researchers and a fellow operator. This involved a procedural change to cable handling that constituted a method of looping the cable in 3-m (10-ft) lengths (as seen in Fig. 3b), so that only a 3-m (10-ft) length of cable is handled at a time instead of a haphazardly overlapping bundle. NIOSH researchers determined that overlapping the cable (as seen in Fig. 3a) while unwinding it increased the force required by approximately one third, i.e., mean forces for small drag at 82.3 N (18.5 pound-force) with no cable overlap versus 113 N (25.5 pound-force) needed when overlapped cable.

This intervention, including training for all workers, was implemented by Gleason Mine management quickly and at no cost. The Gleason mine safety and health supervisor stated that this intervention "was a good partial solution" and was accepted fairly well, although a few operators still try to "manhandle" the cable. This solution, even though not optimal as yet, helped to reduce the amount of load handled by 28% and raised the awareness of the employees while a more cost-effective solution can be further explored. Table 2 presents a summary of the cable handling target task.

Cleaning and maintaining tub. A third intervention concerning the shredder was for the "tub," which requires regular cleaning and maintenance. As above, issues were identified as a result of feedback from the shredder operators. Injury risk factors for this task included awkward postures while climbing into or leaning over the side of the tub to remove large pieces of rock. Before the intervention, employees would climb over the side of the tub to clean it out, to change knives and to remove large pieces of rock and clay. This placed employees in postures that could lead to back and shoulder strains. The tub has a diameter of 1.6 m (62 in.) and is 1.4 m (55 in.) high (measured from the base inside the tub). Considering that half the male population and 95% of the female population have a shoulder height of less than 1.4 m (56 in.), the tub height posed

Figure 4a — Shredder tub with door installed.

Figure 4b — Worker easily removing large rocks when using door.

a significant barrier. Both men and women would have to lean over the rim of the tub to retrieve rocks, typically weighing 23 to 27 kg (50 to 60 lbs) and then throw them over the tub at shoulder height. Mine management was concerned about workers' safety and the potential musculoskeletal injury risks when climbing in and out of the tub, leaning over the tub wall and lifting rocks out of the tub.

A team consisting of mine management, maintenance personnel and shredder operators conducted intensive brainstorming sessions to reach a low-cost effective solution. It resulted in cutting the tub to create a hinged door (Figs. 4a and 4b). This intervention demonstrated the following benefits:

- It reduced the risk factors associated with leaning over the side and climbing over the side of the tub. The worker was now able to walk into the tub to perform cleaning or maintenance duties.
- It reduced the injury risk associated with lifting heavy rocks to shoulder height and above to throw them over the top of the tub side. Instead workers are able to use the door of the tub to easily slide out rocks and debris.
- It allowed operators to safely carry maintenance tools into and out of the tub.

Table 2 — Target task: Cable handling.

Primary risk factors

Forceful exertions while handling heavy and awkward equipment.

Root cause

Tangled cable requires higher force for handling.

Improvement description

A procedural change that constituted a method of looping the cable in 3-m (10-ft) lengths, so that a 3-m (10-ft) length of cable is handled at a time instead of a haphazardly overlapping bundle.

Table 3 — Target task: Cleaning and maintaining tub.

Primary risk factors

- Awkward postures.
- Contact stresses while climbing into or leaning over the side of the tub.
- Forceful exertions while trying to remove large pieces of rock.

Root cause

Lack of acces to tub interior.

Improvement description

Added a hinged door by cutting the side of the tub.

The cleaning and maintaining tub target task is summarized in Table 3. The Gleason mine safety and health supervisor estimated $1,200 as the total cost of this intervention for all three shredders. The supervisor said, "This intervention has been very well accepted. The process of brainstorming by the maintenance department and shredder operators…[with] the solutions reached by the parties involved was good. This was a remarkably simple, but very worthwhile intervention."

Handling sodium silicate. Another task that was improved as a result of the NIOSH-Unimin collaboration was the handling of a clay additive, sodium silicate. The sodium silicate is added in 23 kg (50 lb) increments to the ball clay slurry up to three times a day. Originally the additive was dispensed into a bucket and then carried along a catwalk for about 15 m (50 ft) (Fig. 5a). This catwalk was very narrow and forced workers to carry the bucket one handed in front of or behind their body or to walk sideways.

NIOSH researchers recommended extending the piping for the additive over to its destination to eliminate carrying the load. As shown in Fig. 5b, it would still be necessary to pour the additive into the slurry by bucket, but workers would no longer carry it 15 m (50 ft). The cost of implementing the intervention was approximately $300. The installation was straightforward because the additive was already piped. They simply added a pump and lengthened the pipe. The employees liked the idea and quickly put it in place.

Table 4 — Target task: Handling sodium silicate

Primary risk factors

- Forceful exertions.
- Awkward postures while handling heavy and awkward materials.

Root cause

Station and catwalk were not setup to directly add the additive. The additive has to be manually carried and added.

Improvement description

Extended the additive dispensing pipe to the delivery point to eliminate carrying the load. It is still necessary to pour the additive into the slurry by bucket.

Figure 5a — Pre-intervention handling and carrying of the bucket (arrow depicts walking path).

The implementation of this intervention eliminated carrying the heavy load using awkward postures. The result is a reduction of the risk of sprain and strain injuries to the back and shoulders. Adding a hose with a metered valve to deliver the additive directly without any manual handling could enhance this intervention even further. Table 4 summarizes the handling sodium silicate target task.

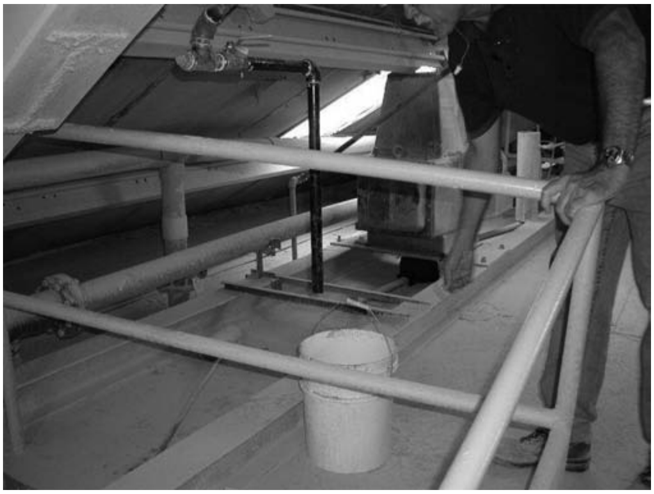

Figure 5b — Post-intervention filling of the bucket (occurs at end of path way shown in Fig. 5a).

Age Awareness Training. Age Awareness Training (AAT) was developed by NIOSH in response to the concern that an increasing number of older mine workers are remaining on the job. The training discusses normal age-related changes that have the potential to affect worker health and safety. Also addressed by the AAT is how these normal changes can be mediated through modifications to the workplace or improvements to personal health behaviors. The AAT includes seven training modules covering topics such as hearing, vision and the musculoskeletal system.

During the collaboration it was determined that at the Gleason facility the median age was 45.5 (range 22 to 68) years and the median length of mining experience was 19.5 (range 0 to 40) years. This diversity of the workforce led to a decision to use Gleason as a field test location for the AAT during the summer and fall of 2006. The first "kick off" module (Introduction) was given at the start of a monthly safety meeting to about 60 employees and was followed with biweekly safety talks on each of the modules. Educating workers on issues related to the physical and cognitive aging process can be an effective way to reduce the possibility of injuries.

The Gleason mine safety and health supervisor commented: "Overall, the vision module (the first to be given in the biweekly format) was received rather well and has provoked some good discussion and a few projects." For example, one intervention resulting from the vision module was applying antiglare film on the windows of the mobile equipment at the mine pit. The effect of glare on an aging population was identified by the module as: "After age 40, changes in the lens and the vitreous gel [of the eye] cause the resistance to glare to decline by 50% every 12 years." Given that older workers may have problems adapting to situations with glare, adding antiglare film reduced the risk of injury to the workers by allowing them to be able to distinguish any possible hazards.

Impact of the interventions

Initially the workforce did not readily accept ergonomics and the application of its principles at Gleason. However, employee buy-in was generated through training and employee involvement in developing the interventions. The workers became more proactive about problem solving and developed and implemented many of the interventions discussed above with little guidance after the initial discussion of ergonomics principles. For the nine-month period from Jan. 1, 2006, through Sept. 30, 2006, there has been only a single MSI reported as compared to the yearly average of approximately four MSIs (for the period of 2000 through 2005). This decrease in MSIs cannot directly be attributed to the interventions, but it may be due to increased awareness of the employees about risk factors. There has also been a noted reduction in the average modified duty days per MSI of approximately 23%. This reduction in modified duty days has resulted in an estimated savings to Gleason of approximately $14,000 in 2006. As the age awareness training proceeds and the application of ergonomic principles becomes part of the mine's culture, additional interventions are expected to be implemented at Gleason over the next few years.

Discussion

Positive results have also been realized in other private sector ergonomics programs, including one studied by NIOSH (Torma-Krajewski et al., 2007) and case studies investigated by the U.S. General Accounting Office (GAO) (1997). Torma-Krajewski et al. (2007) discussed the successful implementation of an ergonomics process at a western surface mine (Bridger Coal) over a three-year period. In a manner similar to the one discussed in this paper, implementing interventions through a participative employee-based process reduced exposure to ergonomic risk factors. The coordinator for the ergonomics process at Bridger Coal stated: "Ergonomics has played an important role in helping Bridger Coal reach our goal of providing the safest and healthiest working environment possible for our employees.... The Ergonomics Program is currently an integral part of our company and we are confident that it will continue to improve and enhance the safe working experience at our mine."

Moreover, GAO (1997) conducted case studies involving five U.S. companies with staffs ranging from 300 to 5,300 employees. The GAO reported that officials at all the facilities believed their ergonomics programs yielded benefits, including reduction in workers' compensation costs associated with MSIs. The case studies also showed reductions in overall injuries and illnesses as well as in the number of days injured employees were out of work and increased worker morale and productivity. The conclusion of the GAO report was "... that positive results can be achieved through an approach incorporating certain core elements that are implemented in a simple, informal, site-specific manner."

Conclusions

Several ergonomic interventions implemented at Unimin's Gleason mine reduced or eliminated a number of risk factors that could lead to injuries. By reengineering the existing safety processes to include the application of ergonomic principles, cost effective interventions were quickly and easily developed by the workers themselves. These efforts also laid the foundation for future interventions and a better understanding of the types of activities and designs that lead to decreased exposure to these risk factors. The success of the interventions described stemmed from its participatory approach to problem solving; empowering all personnel with a voice in health and safety issues. The success achieved at the Unimin Gleason mine is also corroborated by results documented in the NIOSH and GAO studies cited previously (Torma-Krajewski et al., 2007; GAO, 1997).

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Disclaimer

The findings and conclusions in this report 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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