Reducing Musculoskeletal Injuries in Rail Operations

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Introduction

Many mines use rail transport to send their commodity to market, particularly when large volumes of mineral must travel long distances. While rail is an efficient means of transport for mineral products, rail yard operations have often been associated with high rates of musculoskeletal injuries. This is undoubtedly due to the physically demanding nature of jobs in and around rail yards at mining operations.

The keys to reducing musculoskeletal injury risk in mine rail yards are: 1) to reduce the force (or muscular effort) needed to perform tasks; 2) improve the posture of the body; and 3) reduce the duration and/or repetition of physical exertions. Rail tasks historically have been associated with high force requirements and poor positioning of the body (especially bending the torso forward) due to the size and layout of the equipment. However, recent years have seen the development of improved designs or assist devices that have reduced physical demands and/or have improved the posture in which workers can operate. The following sections describe some of the solutions developed to reduce the risk of musculoskeletal injuries in rail yards based on the principles noted above.

Switches

Throwing switches has historically been associated with a high risk of musculoskeletal injuries in rail yards. Figure 1(a) shows an old-style switch which is poorly designed and can place workers at increased risk of back injury. This switch design requires the worker to stoop down to throw the heavy switch, placing the back in a potentially unsafe position, if high forces or incorrect methods are used.

The so-called “bowtie” switch (Figure 1(b)) is a much better design from the ergonomics perspective. The bowtie switch does not require the rail yard worker to bend to the ground to throw the switch, but allows the worker to grab the switch at knee height, which can reduce back stress by up to a third compared to the old design. The long lever arm provided by the bowtie handle permits forces to be applied at a larger distance from the center of rotation of the switch, which reduces the force requirements from the worker. The worker can also use body weight and gravity to complete the switch-throwing process, which will also reduce muscular demands and the risk of injury.

Physical demands associated with throwing switches can be eliminated entirely by using solar-powered switches (Figure 1(c)). Solar-powered switches are more expensive initially (approximately $10,000), but are becoming the standard at larger rail facilities.

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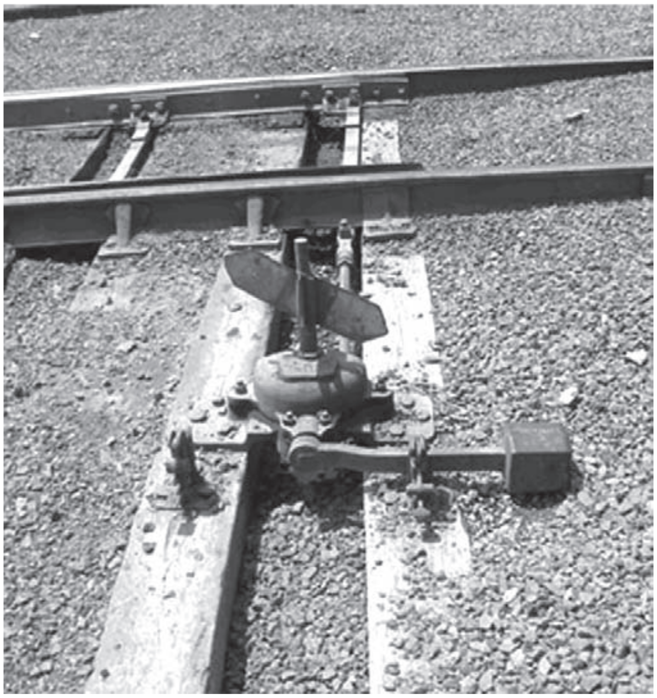
Figure 1. Switch designs: (a) old-style switch requiring awkward bending, (b)"bowtie" switch, (c) solar-powered (automated) switch.

(a) old-style switch

(b) "bowtie" switch



(c) solar-powered (automated) switch.

These new switches eliminate the need to manually throw switches, as the solar-power collected is used to drive an electric motor to throw the switch. This design eliminates the risk of experiencing a costly lost-time injury due to switching. In addition to eliminating the physical demands, these new switch designs often provide other benefits, including remote control capability and remote monitoring of the switch status.

Safe operation of hand-operated rail switches requires regular maintenance. Periodic inspection, adjustment, and lubrication of switches and switch points are needed to keep forces within safe limits. Switch forces can change with the movement of trains and as the result of weather conditions. Use of point roller bearings, correct adjustment, and lubricants such as graphite or white grease (more environmentally friendly) can keep switch forces moderate.

Brake stick

Setting and releasing brakes on railcars is a common rail yard task. In the past, it was necessary to set the brake wheel by climbing up on the railcar and manually turning the wheel to set the brake. Climbing on the railcar both puts the worker at risk of a serious fall and puts the worker in a tenuous position during forceful turning of the brake wheel (Figure (2a)). Use of a brake stick (Figure 2(b)) eliminates the need to climb and hang on to the railcar when setting brakes, and permits the worker to set the brakes more quickly while safely positioned on the ground. Brake sticks permit application of adequate force with very low muscular effort by using gravity and biomechanical advantage. These devices are very popular among rail yard workers.

Figure 2. Setting Brakes (a) after Mounting railcar, (b) using brake stick.

Gate Openers

Gates for each railcar "pocket" (chutes used to dump/unload material from a railcar) are often opened using a heavy steel bar. The worker has to reposition and crank the bar repeatedly in order to open the gate. This is often performed in a hazardous bent back posture (Figure 3(a)). The risk factors of high physical force exertion and bent torso posture place the worker at high risk of back nate the need to manually throw switches, as the solar-power collected is used to drive an electric motor to throw the switch. This design eliminates the risk of back injury. Of particular concern is the unexpected loading that may occur if the bar slips free or the gate is stuck when it is expected to move (as may happen when gates are frozen). Devices are now commercially available that open gates mechanically and which can easily open frozen or stuck gates (Figure 3b). Use of these mechanical gate openers eliminates repeated high force exertions in awkward postures when manually opening gates, reducing back injury risk.

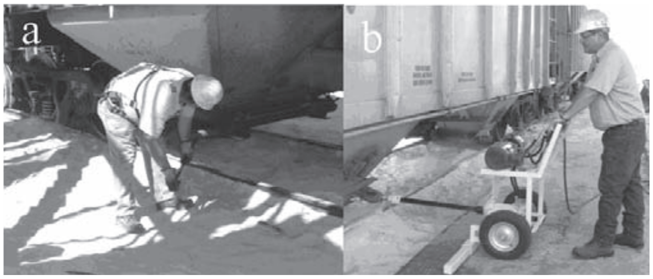


Figure 3. Opening hopper car gates (a) using steel bar and (b) using mechanical gate opener.

Hatch Opener

Some mines transport their commodity in covered hopper cars, especially when keeping the material dry is an issue. These hopper cars often have heavy steel hatches that need to be opened so that material can be loaded. Workers typically open these hatches while standing on top of the railcar which requires them to bend forward to grab one end of the hatch and lift (Figure 4(a)). This again puts the back in a hazardous posture during a heavy exertion. The bending and lifting exertion is repeated when the hatches (again laying flat on the car) need to be closed. Hatches sometimes get stuck or frozen leading to high opening forces (up to 155 pounds!).

Figure 4. Opening covered hopper car hatches (a) manually and (b) using rail hatch opener.

A prototype hatch opener assist device developed by the National Institute for Occupational Safety and Health (NIOSH) is currently being field tested. This device allows the worker to maintain a more upright posture when opening the hatch, and props the hatch open for loading (Figure 4b). Propping the hatch open greatly reduces the stresses associated with closing hatches and the hatch opener can be used to easily control the closing of the hatch. An analysis using a low-back biomechanical model (Chaffin 1997) indicated that low back stress is reduced by approximately 30% when using the device (compressive forces on the low back were 1193 pounds when lifting the hatch by hand versus 835 pounds when using the hatch opener).

Latch opener assist tool

Opening the hatches on covered hopper cars requires releasing a latch that is under spring tension. This requires considerable force due to the short lever arm available on latch arm itself. Workers at one mine rail operation developed an assist device that can be used to effectively increase the lever arm (and the mechanical advantage) available to unload the spring tension on the latch, decreasing

Figure 5. Latch opener assist tool.

the force needed for this task. Figure 5 shows an example of a worker using this device.

Installing railcar shakers

Railcar shakers are sometimes used to help clean out railcars. Shakers are quite heavy (approximately 40-50 pounds) and manual installation on the railcar requires use of a bent back posture creating high stress on the low back (Figure 6(a)). However, carts to facilitate shaker installation have been developed to avoid having to handle or lift the shakers. Figure 6(b) shows an example (American Portland Cement Alliance, 2002). The cart is wheeled up to the hopper car that needs to be cleaned out and is tilted into place. The cart shown below was fabricated by an on-site company shop. Similar (more sophisticated) devices of this sort are commercially available from rail safety suppliers. Eliminating the need to manually lift a heavy railcar shaker greatly reduces low back injury risk.

Figure 6. (a) Manual installation of railcar shaker, and (b) cart developed to install railcar shaker without manual lifting.

Rail yard storage and organization

The author has visited a number of rail operations where frequently used items were poorly stored and the yard disorganized. In many cases, heavy pieces of equipment (hoses, shakers, and other heavy items) were "stored" on the ground, which is unsafe and unproductive (Figures 7(a) and 7(b)). Lifting such items from ground level can triple the risk of a low back injury; compared

Figure 7. (a) heavy railcar shaker "stored" on the ground

Figure 7(b). Poorly organized tools and hoses.

to if they were stored at waist height. Improved storage procedures can eliminate many tripping hazards as well.

Improved organization and storage can play an important role in decreasing injury risk and improving productivity. As an example, a large national railroad company experienced a high rate of injuries at one of its repair facilities (American Association of Railroads 1989). Of particular concern was the high incidence of back injuries, lost time, and absenteeism. For example, the year before changes were instituted at the maintenance yard, 9 of 13 lost time injuries were back injuries, and 579 lost days and 194 restricted or limited work days accumulated. Only 1,564 cars were repaired that year, and absenteeism was 4 percent. Some relatively inexpensive facility changes, such as providing tables and/or racks and better tool storage, reduced the risk of injury and made the workplace more efficient and functional. An example of improved storage can be seen in Figure 7(c). Prior to the development of the table shown, heavy coupler knuckles were tossed in a pile on the ground and had to be lifted using an awkward

Figure 7(c).. Improved rail yard organization and storage: storage table for coupler knuckles allows lifting at waist height rather than from ground.

stooping posture. The coupler knuckle storage table allowed workers to handle these heavy objects at waist height with the back in an upright posture, which can reduce the loading on the low back by up to 65% compared to lifting from the ground. As part of this effort, the company evaluated the back stress of all heavy lifting tasks, and instituted a training program on safe lifting.
Over a four-year period, overall injuries decreased from 33 to 12, back incidents from 13 to 0, lost days from 579 to 0, restricted days from 194 to 40 (all non-back injuries), and absenteeism dropped from 4% to 1% (Table 1). The number of cars repaired per year increased from 1,564 in 1985 to 2,900 over this period, an increase in dollar value of $3.96 million. The company calculated the cost-benefit ratio as approximately 1 to 10 (i.e., one dollar spent on ergonomics changes resulted in 10 dollars in savings).

Summary

Rail operations have long involved heavy physical effort and work in awkward postures, both of which are major risk factors for musculoskeletal problems (particularly back injuries). However, there are many ways to reduce these risk factors, through improved design of switches, development and/or use of assist devices for physically demanding jobs, and better organization and design of rail yard facilities. As noted above, such improvements can reduce injury risk while enhancing productivity in rail operations.

References

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	1985[a]	1986	1987	1988
Total incidents	33	23	10	12
Reportable incidents	29	10	2	7
Lost-time incidents	13	1	0	0
Back injuries	9	0	0	0
Lost days	579	11	0	0
Restricted days	194	15	2	40[b]

[a]1985 data are typical of data for previous 4 years.
[b]Increase is in non-back-related minor injury incidents.

Table 1. Injury experience at a rail repair shop before and after instituting a back injury reduction program (AAR, 1989)