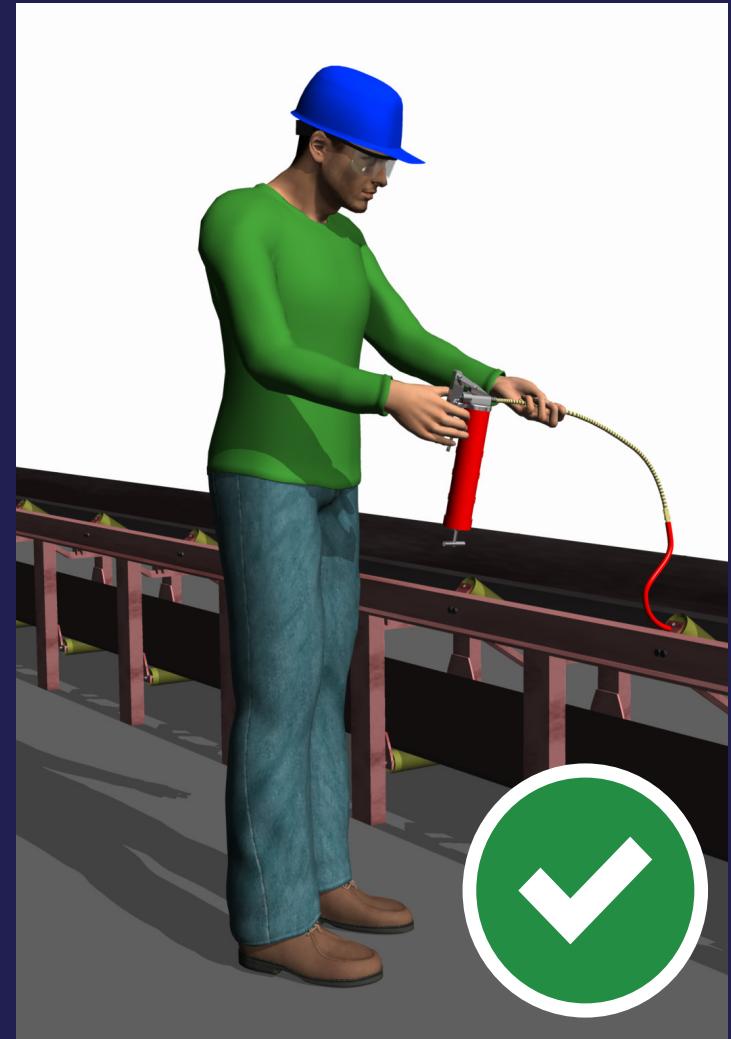
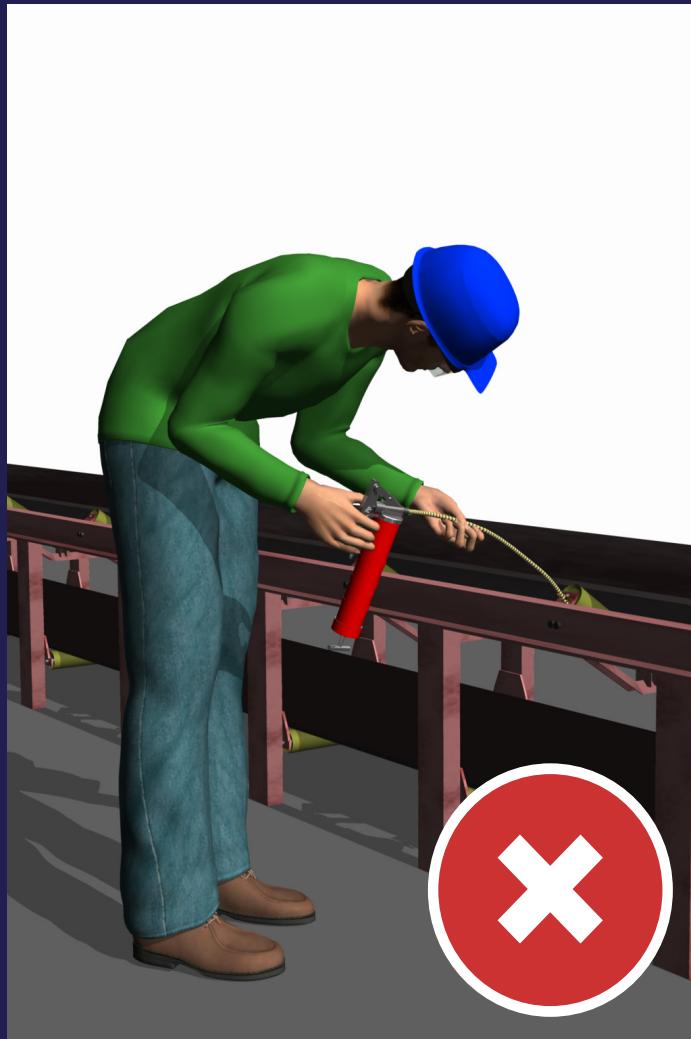


SIMPLE SOLUTIONS FOR SURFACE MINE WORKERS



ERGONOMICS IMPROVEMENTS AT SURFACE MINES



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

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Foreword

This booklet, Simple Solutions for Surface Mine Workers, is designed to provide examples of the types of solutions and task design ideas that you can use to reduce exposure to risk factors for musculoskeletal disorders and slips, trips, and falls. Although the ideas in this booklet are not an exhaustive list, they can be used as a foundation for developing similar types of solutions.

One of the largest categories of injuries in mining is musculoskeletal disorders (MSDs), and a significant contributor to these MSDs and other mining injuries are slips, trips, and falls (STFs). MSDs and STFs can be prevented by identifying risk factors and reducing exposure to these risk factors through ergonomics.

Ergonomics is the science of designing tools, tasks, equipment, and the work environment so that job demands do not exceed the capabilities or limitations of the majority of the workforce (preferably, at least 95%). Properly designed work tasks can lead to safer and more efficient performance of your workers. This is especially true in mining, which is characterized by physically demanding work carried out in a range of dynamic environments.

Most mines (and maybe your own mine) may not have dedicated personnel for addressing ergonomic issues. However, this should not prevent you from making ergonomics improvements. The National Institute for Occupational Safety and Health (NIOSH) has developed a range of tools to assist you with addressing ergonomics needs at your mining operations, including training to teach workers how to recognize and report risk factors for MSDs, guidelines for implementing an ergonomics process, and ergonomics audits for several types of operations. Many of these tools can be implemented by observing work habits and taking fairly simple measurements. Once deficiencies are noted, you can help workers to redesign the tasks to eliminate or reduce the hazards.

Musculoskeletal Disorder Risk Factors

A musculoskeletal disorder (MSD) risk factor is an action or condition that has been found to contribute to discomfort or injury. There are four fundamental risk factors.

- **Forceful Work** is any task or activity where the body must exert high levels of effort.
 - Lifting or carrying heavy objects
 - Forcefully pulling, pushing, or prying
 - Forceful gripping
- **Poor Posture** is when we assume any position other than neutral posture, which makes us less capable of generating force and may cause pinching of nerves.
 - Trunk bent over more than 20° degrees
 - Twisting the trunk or head
 - Working with elbows above shoulders
 - Extended reaches in front of or behind the body
 - Kneeling or squatting
 - Static posture—even good posture is harmful when sustained for a prolonged period
- **Repetitive Work** is when we repeatedly use the same muscles and tissues to perform a task or activity, irritating our tendons, increasing pressure on the nerves, and keeping our body from healing properly.
 - Pinching bags to seal them
 - Manually tightening bolts
 - Using mobile equipment controls such as joysticks
 - Using manual grease guns
- **Vibration Exposure** comes in two forms: hand-arm and whole-body. Vibration exposure can decrease blood flow, damage nerves, contribute to muscle fatigue, and cause low back pain.
 - Driving a haul truck or other mobile equipment on uneven terrain
 - Operating a crusher
 - Using a jackhammer

Note: Multiple musculoskeletal disorder risk factors may occur simultaneously. When more than one risk factor is present, there is an increased risk for injury.

Slip, Trip, and Fall Hazards

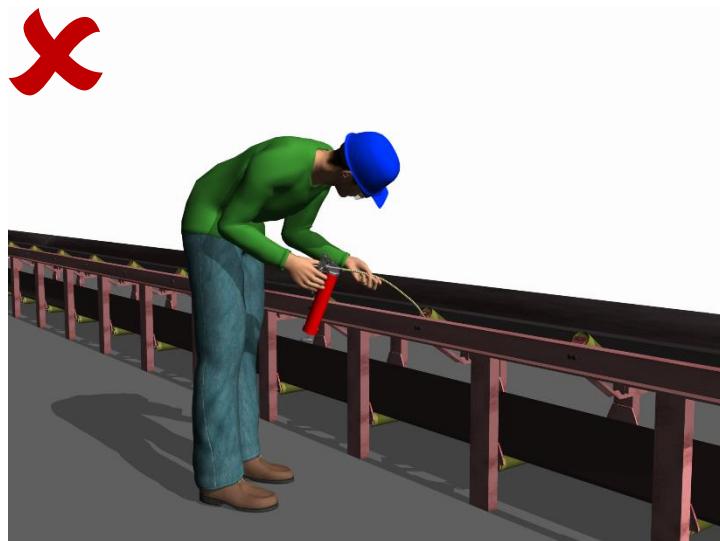
Slips, trips, and falls (STFs) are the second leading cause of injury at surface mines. Below are some common causes.

- **Inadequate Ingress and Egress Systems** create hazards by not accounting for human capabilities. These systems may contain high or inconsistent step heights, lack handrails, or contain uneven thresholds.
- **Unstable Working Surfaces** can initiate falls due to the unexpected movement of the surface. Unexpected movement is a common cause of falls when working on ladders.
- **Inadequate Barriers** may fail to protect workers from falling or fail to prevent inadvertent access to areas not suitable for bearing weight (such as skylights).
- **Not Using Personal Fall Protection Systems** creates a risk of falling that can lead to serious injuries. Improper harnesses or inadequate tie-off locations further increase the risk for serious falls.
- **Not Maintaining Three Points of Contact** may lead to a fall due to a worker's inability to catch himself or herself at the initiation of a fall. Carrying an item in your hand while climbing ladders, stairs, or inclined walkways makes it difficult or impossible to maintain three points of contact.
- **Contaminants on Walking Surfaces** increase the risk of an STF. Some contaminants can be especially dangerous when wet and can increase the likelihood of a slip.
- **Poor Visibility of Walking Surface** reduces a worker's ability to detect and avoid hazardous conditions that may exist on the walking surface. Recognizing the hazard is the first step to eliminating, avoiding, or being careful around it.

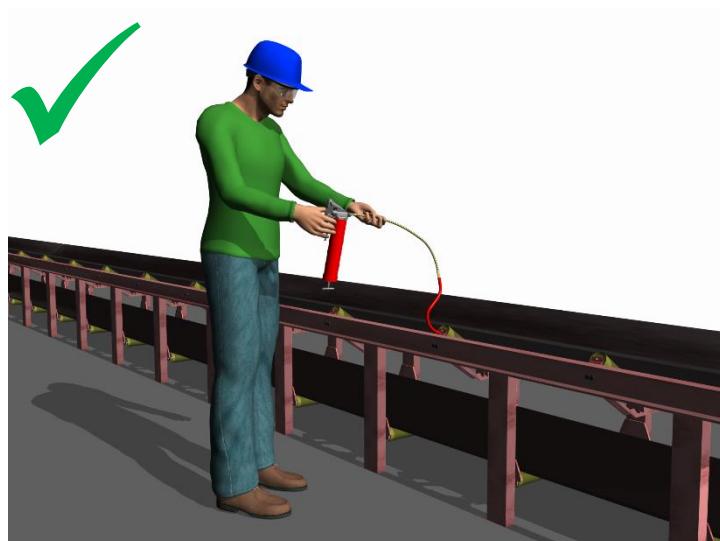
Greasing

Greasing is a routine task at many mine sites. Workers can spend an entire shift walking to different locations throughout the mine to grease belts, motors, and other pieces of equipment. The location of the greasing fittings can make access difficult or require awkward postures.

Risk Factors: poor posture, repetitive work



Problem: Without an access line, the worker has to bend to access the grease fitting and for the remaining time spent greasing.



Solution: Add an access line so the worker can stand upright while greasing.



Additional Improvements: Supply workers with powered grease guns to reduce the repetitive squeezing motion required for manual grease guns. Care should be taken to ensure the weight of a powered gun does not create an additional hazard. Sealed bearings that do not require manual greasing may also be appropriate.

Palletizing

Palletizing is common at many mining facilities where the product is bagged for final use. Often, the workers palletize bags manually by stacking bags in a desired pattern. The act of lifting and lowering bags frequently can cause fatigue and lead to injury. Injury risks are increased only when the locations of the pallets are not ideal or the weight of the bags is excessive.

Risk Factors: poor posture, repetitive work, forceful work



Problem: When starting a pallet, it is common to work on a low surface.



Solution: Provide a self-adjusting lift table to improve access and safety by ensuring workers are working near elbow height. When possible, use a rotating lift table to reduce reaching to access the differing areas on the pallet.



Alternative Solution: If a rotating lift table is too expensive, raise the height of the lower pallet by creating a stack of supporting pallets. Then, palletize the bags mid-height before removing the pallet from the stack and continue to palletize the already stacked pallet on the floor.



Additional Improvements: Provide a vacuum hoist to support the weight of the bags, significantly reducing physical effort associated with manually handling the bags.

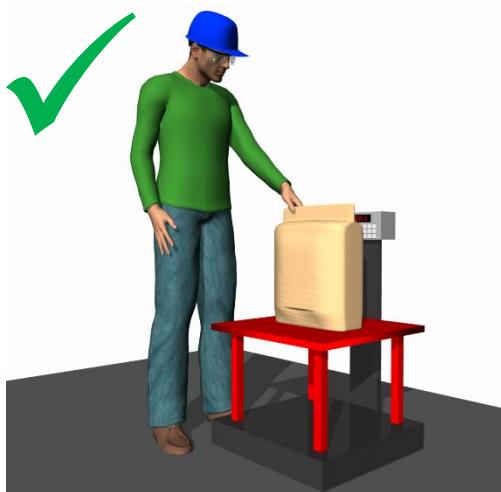
Bag Weighing

Many mining sites bag product manually which is weighed for quality control purposes. Typically, this involves a worker placing a bag onto a scale, and based on weight, adding or removing product. At some sites, every bag is weighed.

Risk Factors: poor posture, repetitive work, forceful work (pinch grip)



Problem: Manually weighing a bag when the scale is on the floor requires bending of the torso while supporting weight.



Solution: Locate the bottom of the scale such that the worker's hands are near waist height when weighing the bag. This scale should be in-line with the bag filling location to eliminate the need to carry the bag to the scale.



Additional Improvements: Bag weighing is a quality control concern. Ensure quality improvements so that routine bag weighing is not needed. Additionally, encourage workers to hold bags using a power grip, not a pinch grip, to reduce forceful gripping.

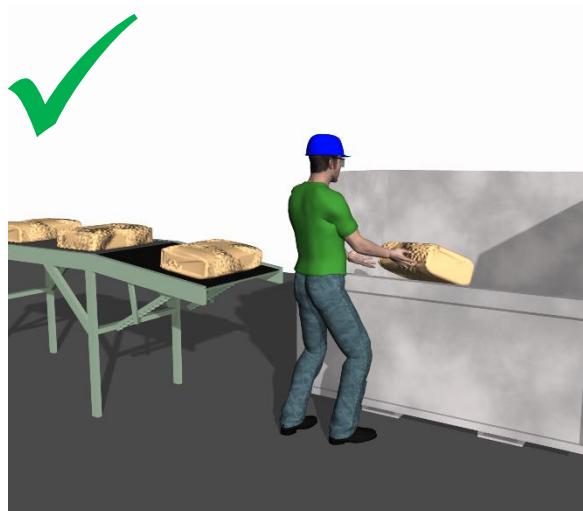
Discarding Items that Fail Inspection

Small bags and other heavy items that fail inspection (due to weight discrepancies or damage) need to be discarded or reprocessed to meet quality standards. These items are often placed into large waste bins or dumpsters to await further processing. The height, location, and design of these bins can threaten musculoskeletal health.

Risk Factors: forceful work, poor posture



Problem: When scrap materials need to be moved from conveyors to dumpsters with a high lip, the material may need to be lifted at or above shoulder height and lead to musculoskeletal injuries.



Solution: Provide a redesigned dumpster with a lowered front edge to facilitate lifting in the power zone between the waist and shoulder. This reduces the stress associated with working at or above shoulder height.



Additional Improvements: Eliminate lifting by having scrap materials and items that fail inspection feed directly into the dumpster.

Shrink Wrapping Pallets

At many mining sites, dry product packaged in bags must be shrink wrapped to keep the moisture out. Once the wrap is applied to the pallet, the worker then walks around with a torch and propane tank to shrink the wrapping and ensure tightness.

Risk Factors: forceful work (lifting)



Problem: A worker may walk around the pallet while holding a heavy propane tank and use a torch to shrink wrap the pallet.



Solution: Supply a wheeled cart for the propane tank. This allows the worker to pull the cart instead of manually carrying the tank, which may weigh over 20 lbs.



Additional Improvements: Mount gas lines overhead. This allows workers to only support the torch, eliminating the need to carry around a tank. Heat guns may also be provided instead of torches as they do not require a worker to transport a tank.

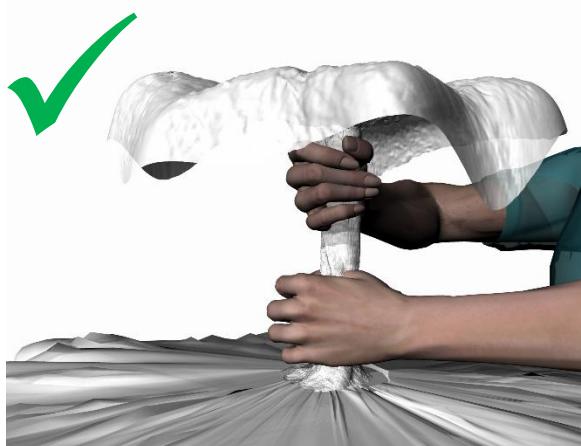
Bulk Bag Closing and Sealing

Nearly all flexible intermediate bulk containers (bulk bags) must be closed, sealed, or both to prevent material from escaping and contaminants from entering the bulk bags. If a particular worker's task is to fill and seal bags only, closing and sealing bags can lead to repetitive strain injuries.

Risk Factors: repetitive work, forceful work, poor posture



Problem: Using the “snaking method” to close bulk bags, where the bag is twisted and then folded over, can require more physical effort than other methods. Using strings, B-locks, cable ties (tie wrap) or wire ties can also require additional physical effort to seal bulk bags, even when applied with pull-twist tools and manual cable tie guns.



Solution: Encourage workers to use the “flowering method” to close bulk bags, where the bag material is just gathered at the top and the worker uses a pneumatic cable tie gun with cable ties to seal the bulk bag. This method lowers injury risk when closing and sealing bulk bags.



Additional Improvements: Attach the pneumatic cable tie gun to a tool balancer.

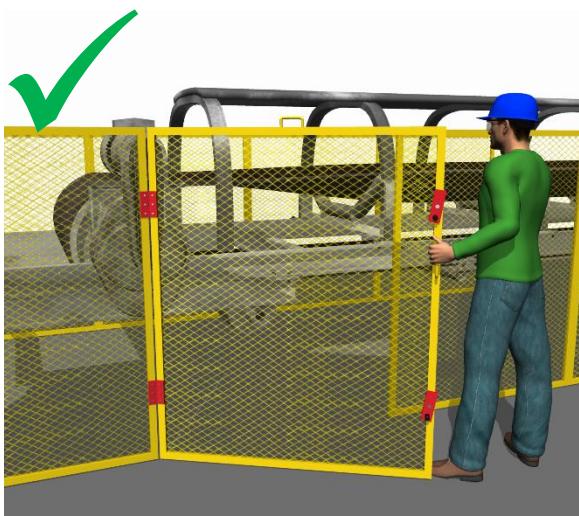
Area Guarding

Area guarding is frequently used to prevent inadvertent contact with dangerous equipment. Guards are often large and heavy and require high force to lift and move. In addition, owing to their size and a lack of handles, area and machine guarding may require awkward postures to lift and move them.

Risk Factors: poor posture, forceful work



Problem: Area guards are typically large, wide, and difficult for one worker to handle manually.



Solution: Design area guards so they are easily handled by a single worker. Guards may be mounted on door hinges that allow them to open easily when access is needed.

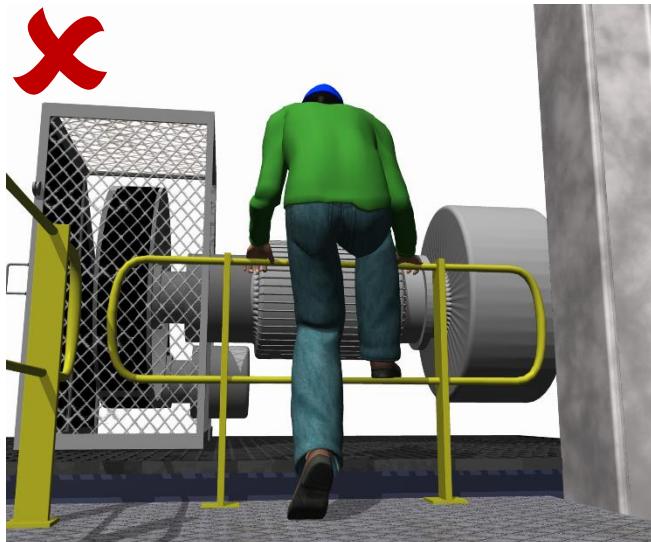


Additional Improvements: Add handles to guards to improve coupling and prevent exposure to pinch points.

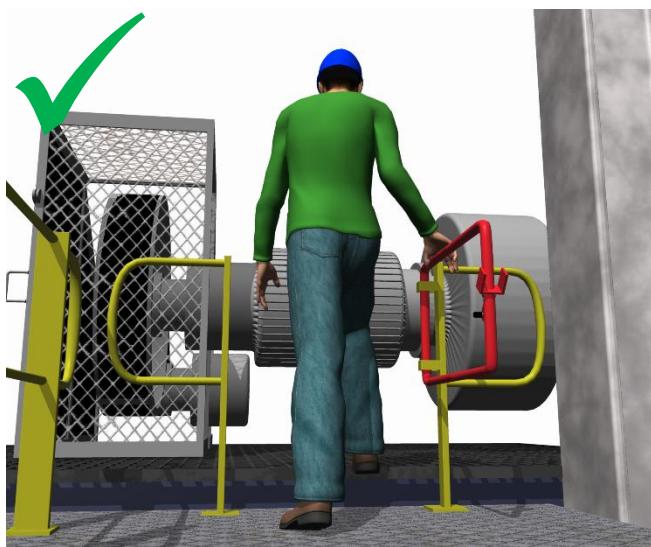
Equipment Access

Equipment access for maintenance and repair is a common issue at mines. Many large pieces of equipment are guarded to prevent unintentional contact with machinery. However, when access is needed, guarding is either removed or defeated to provide access. Designing equipment for maintainability can protect workers from unintentional contact and allow them proper access when needed.

Risk Factors: poor posture, inadequate ingress and egress system



Problem: At some mine locations, workers may be forced to climb over handrails and guards when access is needed to perform routine or emergency maintenance activities.



Solution: Improve equipment access by replacing sections of guarding with secured gates. This prevents workers from unintentional contact with equipment while allowing them access when needed.

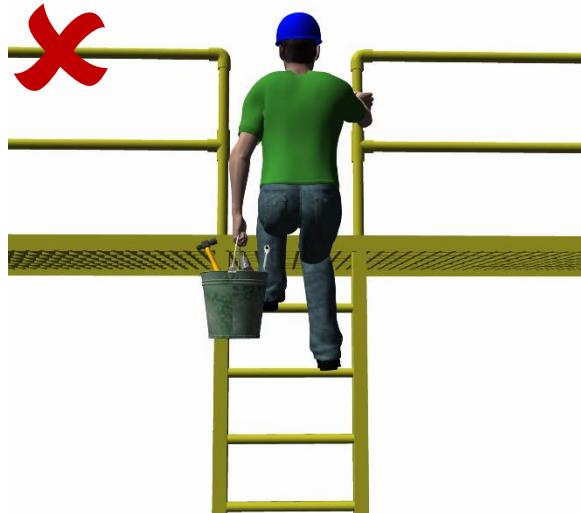


Additional Improvements: Paint all access areas a unique, uniform color allowing workers to easily identify them. Provide signage clearly identifying access areas to encourage workers to use these areas instead of climbing over existing guards.

Transporting Tools or Supplies on Ladders

Many maintenance workers are assigned their own tools that must be transported to their work areas. Unfortunately, many mining plants are prone to very narrow access areas and tool belts can become caught and stuck in these spaces, forcing miners to carry tool bags or buckets. Not only can tool bags be heavy and cumbersome, but they also prevent three points of contact when walking on inclined surfaces, stairs, or ladders. Not maintaining three points of contact when ascending or descending ladders increases fall risk.

Risk Factors: not maintaining three points of contact, forceful work



Problem: A worker climbing a ladder while transporting tools in a bucket or bag is not capable of maintaining three points of contact. This is common among mobile equipment operators who may transport supplies or even lunch boxes onto their mobile equipment while climbing access ladders.



Solution: Supply workers with a backpack to hold light-weight tools while climbing a ladder to ensure safe transport of tools while maintaining three points of contact. If the tools or supplies are heavy, they should not be carried (even in a backpack) up or down a ladder.



Additional Improvements: Store frequently used tools at multiple locations and on all levels so that workers won't need to transport several tools around the facility to complete assigned tasks.

Transporting Supplies into and out of Mobile Equipment

Mobile equipment operators often need to transport supplies with them when getting on or off of equipment. These operators carry work items such as cleaning supplies or personal items such as a lunch box.

Risk Factors: not maintaining three points of contact, forceful work



Problem: A driver climbing a ladder or stairway when boarding mobile machinery and carrying a lunch box is not able to safely maintain three points of contact.



Solution: Supply drivers with a backpack to transport their personal items safely while maintaining three points of contact.

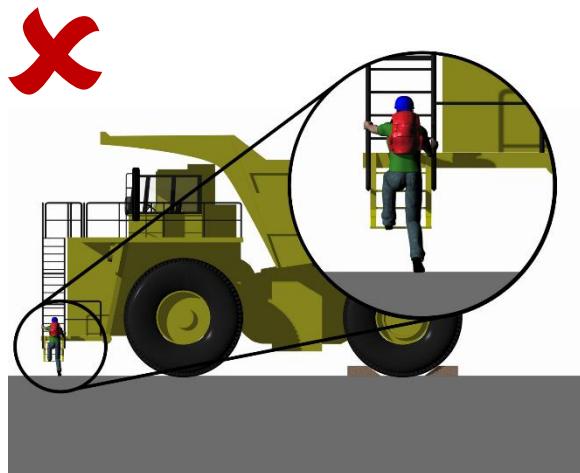


Additional Improvements: In some cases, operators need to transport work supplies in addition to their personal items into the cab. When possible, store tools and supplies required for routine maintenance/cleaning in the cab or on the mobile equipment's platform.

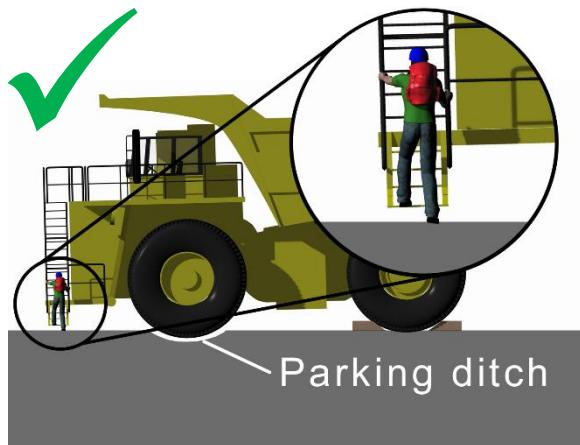
Reducing the Height of the First Step on Mobile Equipment

The first step of a ladder on heavy mobile equipment may be awkwardly higher than is comfortable for a worker to get on and off safely.

Risk Factors: inadequate ingress and egress system



Problem: When parking heavy mobile equipment on a level surface, the distance from the ground to the first step of the access ladder may be large. This makes ingress more strenuous and can increase injury risks when stepping off of the equipment.



Solution: Create a parking ditch in a designated parking area. Resting the front wheels in the ditch lowers the height of the front of the equipment, and thereby decreases the height of the first step. This serves also to further immobilize the equipment.



Additional Improvements: Design a parking area with an access platform and stairs that allow mine workers to access the equipment at cab level.

Equipment Refueling

Fueling mobile equipment often requires working above shoulder height. This is a poor posture that can increase the stress at the shoulders and back.

Risk Factors: poor posture



Problem: Mobile equipment fueling stations commonly have nozzles and fueling points located at or above shoulder height. Similarly, the gas tank cap may also be located above shoulder height. Reaching above shoulder height can increase the risk of injury to the arms and shoulders.



Solution: Add portable or permanent access platforms or step stools to areas where fueling or lubricating occurs. This encourages workers to use them while fueling or lubricating mobile equipment, such as haul trucks, at the ideal working height near waist level.

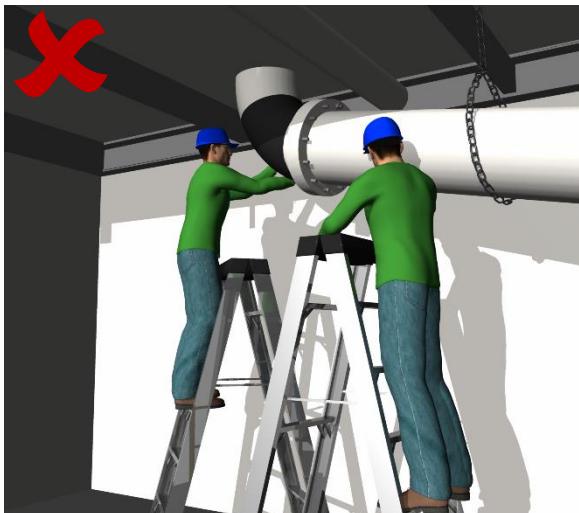


Additional Improvements: Install hose reels to prevent fuel lines and hoses from becoming tripping hazards or requiring forceful work to move and carry.

Scaffolding

Maintenance tasks frequently require multiple workers to ensure safety. When working on elevated objects, workers may choose to use multiple ladders.

Risk Factors: unstable working surface



Problem: Two workers using ladders near each other is a safety concern. If either loses balance or control, it may result in a fall for one or both workers.



Solution: Supply scaffolding when multiple people are working on elevated objects. Care must be taken to ensure that workers are not situated above the highest level of the scaffold and that the platform is guarded on all sides. If scaffolding is designed and used appropriately, it can also eliminate the need to use personal fall protection.

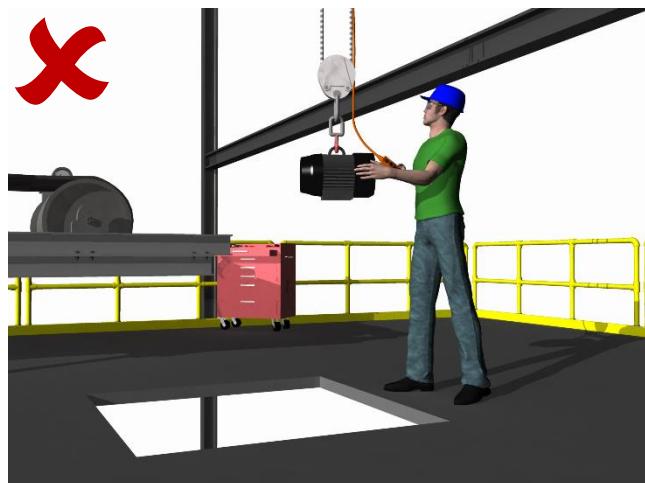


Additional Improvements: Provide scaffolding materials in multiple locations and on all levels within facilities to decrease material handling.

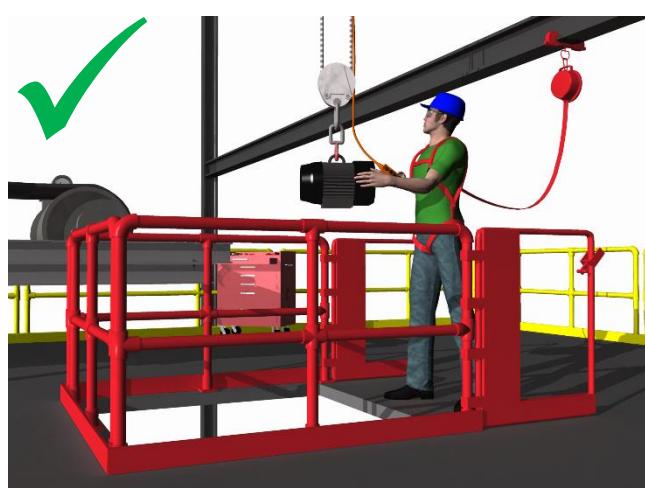
Working around Floor Openings

Floor openings are often used to move material, supplies, and equipment from one level to another and can be created when parts of the floor are removed for replacement. Working around openings in the floor can pose a significant fall hazard.

Risk Factors: inadequate barriers, not using personal fall protection systems



Problem: Individuals can fall through a floor opening that lacks appropriate barriers or if they are not using a personal fall arrest system.



Solution: Encourage workers to use a personal fall arrest system when working near the opening of any unguarded area. Having only one side of an opening accessible with a safety gate and providing barriers on all other sides can further prevent falls through the opening.

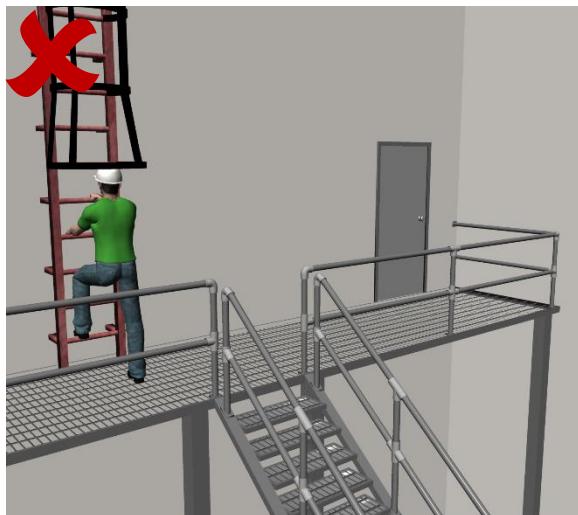


Additional Improvements: Guard, clearly mark, and identify floor openings or other non-weight bearing locations (such as skylights) when permanent barriers are not in place due to active work.

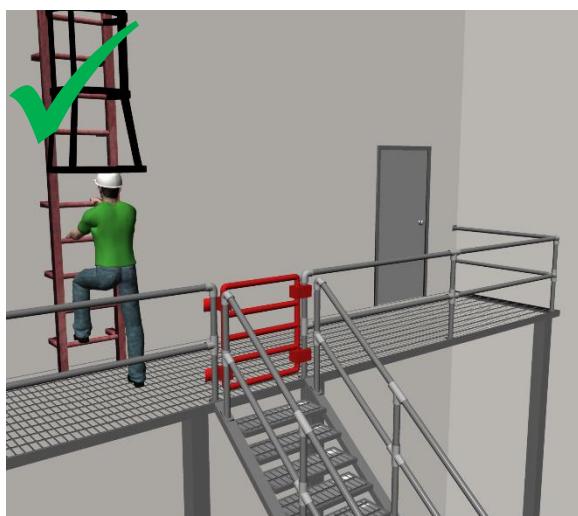
Shared Landings

In many mining facilities, fixed ladders and stairways are commonplace. In some locations, a fixed ladder may share a landing with a stairway. In these areas, the risk of falling may increase due to the proximity of the ladder landing and the entrance to the stairway.

Risk Factors: inadequate barriers



Problem: Shared landings create unique hazards at facilities because a fall from a ladder can also cause a fall down the stairs.



Solution: Ensure the tops of stairways and ladders are offset and equipped with self-closing gates that open inward to reduce the potential for workers to fall.

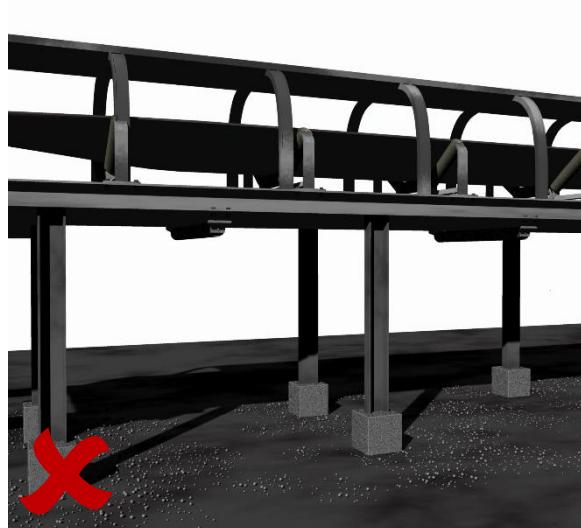


Additional Improvements: Block and guard stairs, gates, and doors to prevent inadvertent contact with the ladder when using temporary ladders close to stairs.

Maintaining Clear Walkways

When using a mechanical system such as a conveyor or belt to transfer materials, there is a potential for some spillage, resulting in contamination of neighboring walkways with debris or loose product. Spillage of material into designated walking areas poses a significant risk for a slip, trip, or fall accident.

Risk Factors: contaminants on walking surface, poor visibility of walking surface



Problem: Spillage from conveyors and belts can encroach onto neighboring walkways or paths of travel and lead to a slip or fall. When wet, some materials can be especially dangerous in that these materials may increase the likelihood of slips.



Solution: Add a barrier adjacent to the walkways to prevent spillage from entering walkways and causing slips. For example, a toe plate added along a conveyor and adjacent to the walkway could stop conveyor spillage from entering the walkway. If the toe plate is brightly colored and clearly marked, it helps prevent tripping when working close to or under the conveyor.



Additional Improvements: Fix spillage at the source to prevent it from collecting on the walking surface.

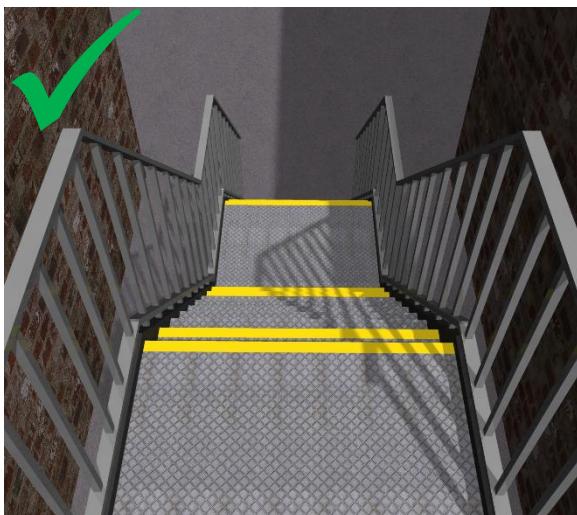
Visibility of Stair Edges

When the edges of stairs (nosing) are not clearly discernible, workers can misstep, trip, or fall. This is especially true when descending stairs, and in conditions when ambient lighting is not ideal.

Risk Factors: poor visibility of walking surface



Problem: When the edge of the stairs (nosing) is not clearly visible, it can lead to trips, missteps, and falls.



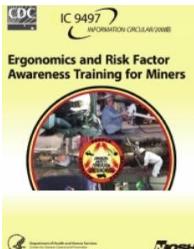
Solution: Clearly mark and highlight the edge of the stairs (nosing) using caution yellow or other high-contrast paint to increase the visibility of the nosing.



Additional Improvements: Increase ambient lighting to ensure visibility of all walking surfaces. Additionally, install a high-contrast non-skid/non-slip plate or use abrasive paint to highlight the nosing on stairs while increasing traction.

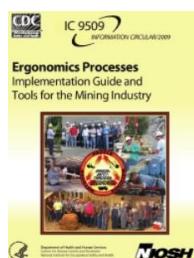
Additional Resources

Reducing exposures to musculoskeletal disorder risk factors can be simple! The NIOSH Mining Program has a number of resources available to further aid you in identifying and reducing ergonomic risk factors at your mine sites.



Ergonomics and Risk Factor Awareness Training for Miners was developed to help reduce injuries and illnesses resulting from exposures to risk factors. The training is designed specifically for the mining industry and should increase awareness of risk factors and encourage miners to take action to report and reduce their exposures to risk factors.

Download: <https://www.cdc.gov/niosh/mining/works/coversheet582.html>



Ergonomics Processes: Implementation Guide and Tools for the Mining Industry was developed to help mining companies establish ergonomics processes at their sites.

Download: <https://www.cdc.gov/niosh/mining/works/coversheet597.html>



ErgoMine is an ergonomics audit tool designed specifically for mining. It includes audits for bagging, haul truck, and maintenance and repair operations at surface mining and processing facilities. Based on your responses to the audit questions, ErgoMine provides recommendations when there is an opportunity for ergonomics improvement.

ErgoMine can be downloaded for free on Android devices from the Google Play Store.

Download: <https://www.cdc.gov/niosh/mining/works/coversheet1906.html>



Slip, Trip, and Fall Hazard Identification, Investigation, and Remediation at Surface Mining Facilities is a NIOSH project to reduce slips, trip, and falls at surface mining facilities.

Visit: <https://www.cdc.gov/niosh/mining/researchprogram/projects/HazardIdentification.html>



NIOSH Ladder Safety App is a mobile application designed to improve extension and step ladder safety.

Visit: <https://www.cdc.gov/niosh/topics/falls/mobileapp.html>



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