



SAFETY

PREVENTING SLIPS, TRIPS AND FALLS FROM FRONT-END LOADERS

Researchers share insights from two decades of findings on equipment injuries. **BY JONISHA POLLARD AND MAHIYAR F. NASARWANJI**

Front-end loaders are the workhorses in mining and are ubiquitous to many operations.

Unfortunately, slips, trips and falls (STFs) are also commonplace at mine sites. Many non-fatal injuries occur when getting on (ingress) and off of (egress) equipment at surface mines.

Mobile equipment, such as front-end loaders, tractor-shovels, payloaders, high-lifts and skip loaders, account for the largest proportion of these non-fatal injuries. The high prevalence of slip and fall injuries when getting on and off of equipment, especially front-end loaders, highlights the need to improve the safety of this critical activity.

Researchers at the National Institute for Occupational Safety & Health (NIOSH) examined 20 years of injury data to determine the injury causes, contributing factors and equipment characteristics associated with STFs on front-end loaders. Our key findings and recommendations from that analysis can be used by mining companies to

improve worker safety during ingress and egress from front-end loaders.

FINDINGS

Most STF injuries (63 percent of the 1,457 incidents examined) occurred when front-end loader operators were egressing from their equipment. In addition, more than 75 percent of injuries occurred when the operator was on the ladder or steps.

Losing contact with the ladder due to a misstep, slip or balance problem was a common cause of injury, contributing to 53 percent of the examined injury records.

Environmental conditions often contributed to these STFs. We found that water, ice, snow, grease, oil and mud accounted for 21 percent of the identified contaminants on the equipment ladder when slips occurred.

The condition of the ground in the parking area is also a concern. Slippery or uneven ground conditions such as mud, ruts, rocks and debris on the ground were the only identified contributing

NIOSH researchers pored over two decades of injury data to determine the injury causes, contributing factors and equipment characteristics associated with slips, trips and falls on front-end loaders.

PHOTO COURTESY OF CASE CONSTRUCTION EQUIPMENT

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factor when the operator was injured due to stepping on or in something when stepping from the ladder onto the ground.

While environmental factors, personal factors and individual climbing styles may influence fall risks, the design and condition of the ingress/egress system also play significant roles in preventing falls. Most front-end loaders have ladders, steps, platforms or some combination of these for ingress and egress. Previous research has found that vertical ladders increase the potential for a foot or hand slip as compared to inclined ladders.

In our study, more than 78 percent of the front-end loader operators were injured on loaders with vertical ladders. Bottom rungs that are high off the ground (at heights greater than 14 to 16 in.) will also make ingress and egress more strenuous, because more effort is needed to ingress and the impact on the ground when egressing can be higher.

A unique feature of ladders on mobile mining equipment, including front-end loaders, is the use of bottom rungs with flexible side rails made of wound wire cables, chains or rubber that extend below the frame of the equipment. These ladder rungs are designed to deflect when encountering rough or



The combination stairway and ladder with two rubber-sided bottom rungs is an example of a ladder rung with flexible rails commonly used as part of the ingress/egress system on front-end loaders.

uneven terrain while remaining securely attached to the ladder system.

This is an important practical feature because ladder rungs with fixed side rails that extend below the frame of the truck would be at high risk for damage or removal when driving around a mine site.

The photo above shows an example of a ladder rung with flexible side rails commonly used as part of the ingress and egress system on mobile mining equipment. While this is just one example showing a way to reduce the height of the first rung, such a design concept may also create additional risks if it causes excessive or unexpected motion of the rung during ingress or egress.

Our study found that more than 62 percent of the identified front-end loaders associated with STF injuries had ladders with at least one rung with a flexible rail.

Most injuries occurred while egressing the equipment.

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Numerous factors may contribute to STFs during egress, including gravity accelerating the body downward and decreased ability to see the rungs beneath one's feet when facing the ladder during descent. This poses a challenge to judging distance to the subsequent rung and the ground, identifying contaminants on the ladder rung, or identifying ground conditions such as rough, uneven or slippery conditions that may lead to a fall.

The slips and step-on/in injuries found in our analysis indicate unsafe ladder and ground conditions may be present at many mines.

RECOMMENDATIONS

Based on our analysis, ingress and egress safety on front-end loaders could be improved through design, maintenance and housekeeping of ladders and parking areas. We offer six key recommendations based on our research.

1. Ensure consistent rung heights from the ground level, through the ladder and to the cab. Most ladder standards, including those for mobile and fixed machines, recommend consistent spacing between rungs (ISO14122-4-

The majority of injuries from slips, trips and falls occurred when workers were getting off of equipment.

2014 4.4.1.1; OSHA CFR 29 1910.23(b)(1); ANSI-ASC A14.3e 2008 5.1.1; ASAE S412.1 MAR1990 (R2014) 3.2.1.1).

However, inconsistent rung spacing is common on mobile mining equipment, especially between the ground and the first rung, between the rungs with flexible rails, and between the flexible and rigid railed rungs. These inconsistent rung heights may play a role in the high prevalence of slips, missteps and loss of footing injuries when getting off mobile mining equipment. Ensuring consistent rung heights from the ground level, through the ladder and to the cab may prevent injuries from occurring on ladders.

2. Provide designated parking areas free of hazardous ground conditions. Unsafe ground conditions can be

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Designated parking areas should be free of uneven terrain like rocks, holes, ruts and surface contaminants.

minimized by providing designated parking areas where ground conditions are regularly monitored and maintained.

Designated parking areas should be free of uneven terrain like rocks, holes, ruts and surface contaminants like snow, ice, mud, oil and grease. Numerous slips and injuries due to stepping on or in something on the ground were identified in our study with uneven surface and surface contaminants as contributing factors. This indicates unsafe ground conditions at parking locations.

Uneven surface and surface contaminants pose a higher threat during egress, because it is difficult to visually identify the hazards and there may not be an easy way to avoid the

This **Department of Health & Human Services** promotion offers several steps to elevate ladder safety.

hazard while egressing from the equipment. Providing designated parking areas free of hazardous ground conditions will improve safety.

3. Provide adequate lighting to improve detection of hazardous ground or ladder conditions. Although engineering controls are preferable, hazard recognition, and then avoidance, by the operator is critical and can be facilitated by providing at least 5 foot-candles of illumination on and around the ingress/egress system and on the ground (OSHA CFR 29 1926.56(a)).

When facing the ladder during descent, it is difficult to see where the feet are landing. This poses a challenge to judge the distance to the next rung or to the ground, to identify contaminants on the ladder rung, or to identify and avoid ground conditions that may lead to a fall. Providing adequate lighting in parking areas may improve the operator's ability to detect hazardous conditions.

4. Ensure adequate handholds are provided for the length of the ladder and into the cab. To prevent an STF injury, you must eliminate the hazardous condition or conditions that led to the incident.

Still, once a slip or trip has occurred, recovery is one way

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to prevent a fall or potentially reduce the severity of the slip or trip. Our findings show that recovery occurred only 25 percent of the time during an STF. Ensuring that adequate handholds are provided for the length of the ladder into the cab may increase the potential for recovering from a slip or trip and thereby prevent falls.

Handholds should be designed in 1- to 1.5-in. diameters and with at least 3 in. of clearance. Ideally, horizontal handholds should be provided as research has shown them to be more effective at preventing falls than vertical handholds.

5. Construct ingress/egress platforms with stairs that allow operators to access the cab of the equipment without ascending or descending ladders. For many front-end loaders, there may be an option to eliminate the previously identified hazards associated with ingress or egress on ladders by providing an elevated platform equipment with stairs.

This will provide more stable and safer access into and out of the cab because ladders pose a greater risk for severe injury than stairs.

6. Regularly and thoroughly inspect and maintain

Handholds should be designed in 1- to 1.5-in. diameters and with at least 3 in. of clearance.

ingress/egress systems on mobile equipment. Inspecting and maintaining ingress/egress systems on mobile equipment allows you to:

- Identify and prevent potential failures
- Fix broken or damaged components of the ingress/egress system
- Ensure all rungs are present and securely attached to the ladder system to prevent unexpected movement
- Eliminate debris and contaminants from the ingress/egress system

We found that equipment failure (such as a rung breaking) and unexpected movement (such as excessive movement of cab doors or ladder rungs with flexible rails) were the leading identified contributing factors to STFs.

Regular and thorough inspection, maintenance and repair can prevent failure, eliminate excessive movement of rungs, and ensure all parts of the ingress/egress system are in good working condition.

LADDER SAFETY

Ladder safety extends beyond just mobile equipment ingress/egress, and similar approaches can be used to improve safety when using many types of ladders at mine sites.

The Steps to Ladder Safety poster (page 70) outlines good practices when ascending and descending ladders. It can be downloaded from <https://go.usa.gov/xN42V>, printed and posted where ladders are used to remind mine workers of the simple steps they can take to ensure their safety when using ladders.

In addition, NIOSH released a Ladder Safety App that is a useful tool for extension and step ladder safety. It can be downloaded from <https://go.usa.gov/xRQH8>. **P&Q**

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